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TECHNO ECONOMIC EVALUATION DIVISION

THE PHILIPPINE
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THREE ISOMERIC ALKALOIDS FROM *UNCARIA PERROTTETII* (A. RICH.)MERR. (*UNCARIA FERREA* F. VILL. NON D.C.)*

By GLORY C. LLEANDER**
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(Received for publication, July 13, 1973.)

ABSTRACT

Three isomeric alkaloids have been isolated from *Uncaria perrottetii* (A. Rich.) Merr. Based on spectroscopic data and comparison with authentic samples, two of the three isolated alkaloids have been identified as pteropodine and isopteropodine.

Uncaria perrottetii (A. Rich.) Merr., a dicotyledon of the family Rubiaceæ, also known as 'baluklitu', is a plant native to the Philippines. In tests performed on the various extracts of the plant by the Medical Research Center, National Institute of Science and Technology, it was discovered that the alkaloid containing fraction of the plant exhibited slight antitumor activity. An investigation of this fraction was initiated in an attempt to isolate and identify the chemical nature of the antitumor substance or substances. In the course of our investigation, three isomeric alkaloids were isolated. We now report on the isola-

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* This paper is dedicated to Dr. Alfredo C. Santos on his 73rd birthday, August 15, 1973.

** To whom correspondence is to be directed.

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STI-12-8720

tion and partial characterization of these three isomeric alkaloids.

In the Philippines, there are at least eight species of *Uncaria* which are found in various parts of the archipelago. Native to the Philippines are the following species:

1. *U. perrottetii* (A. Rich.) Merr. (Syn. *Sabicea perrottetii* Rich.; *Ouroupartia perrottetii* Bail.; *U. ferrea* F. Vill. non D.C.; *U. hookeri* Vidal)
2. *U. insignis* D.C. (Syn. *Nauclea rotundifolia* Bartl. ex. D.C.; *Nauclea, haenkeana* Stend; *Nauclea luzonensis* D. Dietr.; *U. sclerophylla F.* Vill.)
3. *U. setiloba* Benth. (Syn. *Uncaria florida* Vidal)
4. *U. pedicellata* Roxb.
5. *U. canescens* Korth.
6. *U. pteropoda* Miq.
7. *U. philippinensis* Elm.
8. *U. clavisepala* Elm.

The procedure used in the isolation of the alkaloids is shown in the following scheme:

ISOLATION PROCEDURE

(Drug 500 g)

Methanol extraction
(Soxhlet)

Marc | Methanol extract
conc. at 45° in vacuo; allowed
to cool in ice box; filtered

Solid
(nonalkaloidal) | Filtrate
(+) for alkaloids; further concentrated to thick residue;
taken up with 1 per cent HCl;
filtered

Solid | Filtrate
Basified with ammonia;
Ether extraction

Ether extract
concentrated
Light yellow residue
Total alkaloids, at least seven spots on TLC
Residue taken up with minimum amount of ether; filtered

Aqueous phase
(−) for alkaloids

White solid
2 x recrystallized from ether
(two spots on TLC)
m.p. 207 – 209°C
Dissolved in benzene;
Benzene extract

Yellow soluble fraction
Purified to yield
(U – 3)
m.p. 210 – 212°C
(Yield — 0.2 per cent)

Taken up with 0.2N acetic acid

Benzene extract
concentrated
White crystals
(U – 1)
m.p. 205 – 206°C
(Yield — 0.08 per cent)

Acid extract
Basified with 0.1 per cent NH_3
to pH 7.5, Ether extraction

Ether extract
(U – 2)
m.p. 208 – 210°C
(Yield — 0.04 per cent)

Aqueous
(discard)

A 500-g sample of the stem bark and roots of *U. perrottetii* was extracted with methanol in a Soxhlet apparatus. The methanol extract was concentrated under reduced pressure and allowed to cool in an ice box. A reddish brown nonalkaloidal solid separated upon cooling which was removed by filtration and the filtrate was further concentrated to a thick residue. The residue was treated with 1-per cent HCl until the last acid extract gave negative test with Mayer's reagent. The acid extract was basified with dilute ammonia and exhaustively extracted with ether. The combined ether extracts were washed with distilled water, dried over anhydrous Na_2SO_4 and ether was recovered. The concentrated ether extract was allowed to stand overnight in an ice box. A crop of white crystals separated out and was decanted from the mother liquor A. The crude crop of crystals was twice recrystallized from distilled ether. The supposedly purified crystals gave m.p. 207–209°C, which gave two spots on thin layer chromatography (TLC) over silica gel G, using hexane-ethyl acetate (1:1) as solvent system. The semipurified crystals were dissolved in benzene and the benzene solution was taken up with 0.2 N acetic acid until the last acid extract gave negative test with Mayer's reagent. The benzene extract was washed with distilled water and dried over anhydrous sodium sulfate and concentrated under reduced pressure. The concentrated extract, upon allowing to stand at room temperature, yielded white crystals, m.p. 205–206°C, homogenous on TLC. The acid was basified with 0.1-per cent ammonia and extracted with ether. The ether fraction yielded chromatographically pure crystals, m.p. 208–210°C.

The mother liquor A was partitioned between benzene and 0.2 N acetic acid. The benzene solution yielded white crystals, m.p. 210–212°C. The acid extracts were basified with 0.1-per cent ammonia and extracted with ether. The ether fraction yielded impure crystals.

The three alkaloids have been arbitrarily referred to as U-1, U-2, and U-3. Thin-layer chromatography on silica gel indicated these alkaloids to be pure compounds and have the following Rf values and m.p.:

	Melting point	R_f*
U-1	205-6°C	0.40
U-2	208-10°C	0.24
U-3	210-12°C	0.42

The ultraviolet and infrared spectra** of U-1 and U-2 are similar to those of isopteropodine and pteropodine, respectively, (Table 1 and 2) suggesting the presence of an oxindole chromophore and $CH_3OOC — C = CHOR$ group.

TABLE 1. — *Ultraviolet spectra in ethanol.*

	λ min (mμ)	log ε	λ max (mμ)	log ε	shoulder (mμ)	log ε
Isopteropodine†	225	4.00	246.0	4.22	280	3.27
U-1	225	4.06	244.5	4.25	280	3.34
Pteropodine†	225	3.93	246.0	4.20	280	3.25
U-2	225	3.92	244.5	4.23	280	3.27

---

* Solvent system used: hexane-ethyl acetate 1:1.

** Through the kindness of Dr. Gunther Wulff, University of Bonn, Germany.

† G. B. Yeoh *et al*, Tetrahedron Lett., 9 (1966), 931.

TABLE 2. — *Infrared spectra is (KBr) cm-1.*

	Isopteropodine[†]	U-1	Pteropodine[†]	U-2
–NB	3415	3415	3415	3415
–C=O	1700	1700	1708	1700
⌬	1627	1620	1627	1620
Cyclic ether	1081	1080	1077	1085

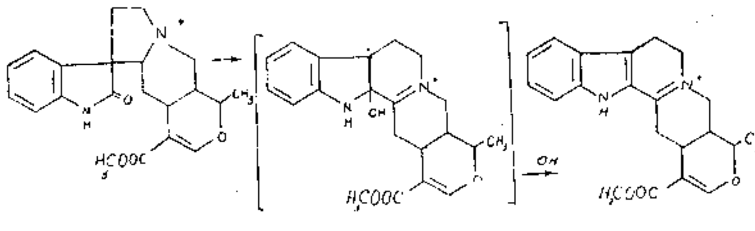
The NMR spectra* of the isolated alkaloids are shown in Table 3 together with reported values[††] for isopteropodine and pteropodine.

TABLE 3. — *NMR spectra (in $CdCl_3$ at 60 MC per second in ppm from TMS).*

	Isoteropodine		U-1		Pteropodine		U-2	
CH_3CHO	1.65	(doublet)	1.55	(doublet)	1.60	(doublet)	1.45	(doublet)
CH_3COO	3.82	(singlet)	3.56	(singlet)	3.80	(singlet)	3.60	(singlet)
Aromatic H	7.28	(multiplet)	7.32	(multiplet)	7.30	(multiplet)	7.28	(multiplet)

The mass spectra* of the three alkaloids show a molecular ion peak at 368, showing that these alkaloids are isomeric. U-1 and U-2 show typical oxindole fragmentation pattern like mitraphylline. However, the fragmentation pattern of U-3 is different from U-1 and U-2.

Furthermore, the mass spectra of the three alkaloids exhibited a small but recognizable M-17 peak (m/e 351) which must be due to the loss of a hydroxyl. This peak was observed by Djerassi *et al*[†††] in the mass spectra of all oxindole alkaloids studied. Since this fragment occurs in substances which contain no hydroxyl group, its formation must involve the loss of the lactam oxygen together with the hydrogen atom which is only feasible if there is an oxindole-indole conversion thus:



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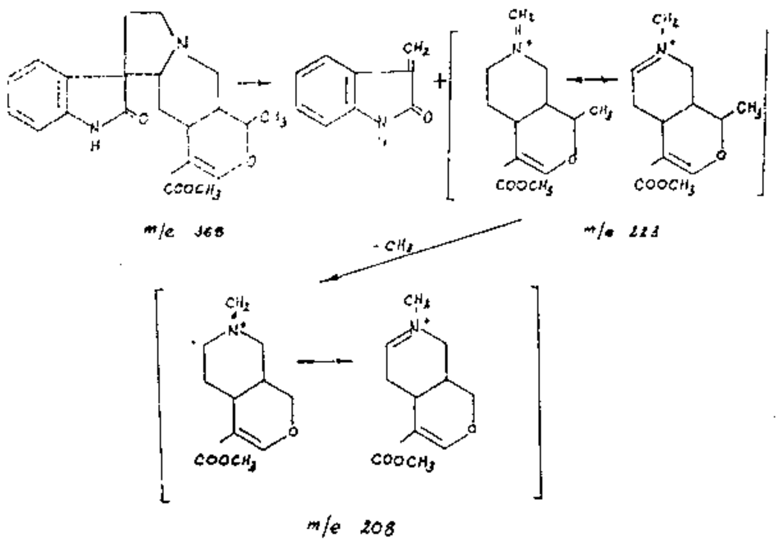
* Through the kindness of Dr. Gunther Wulff, University of Bonn, Germany.

[†] G. B. Yeoh *et al,* Tetrahedron Lett., 9 (1966), 931.

[††] K. C. Chan *et al,* J. Chem. Soc., (c) 24, (1966), 2245.

[†††] J. Am. Chem. Soc., 85 (1963), 1523.

The most intense ion in all the spectra of the isolated alkaloids occurs at m/e 223. This can only be derived from the alicyclic portion of the molecule, since the same strong peak was also observed in the mass spectrum of mitraphylline as reported by Djerassi *et al.* The most logical explanation for m/e 223 may be represented as follows:



A careful consideration of the data available, as well as comparison with authentic samples, showed that U-1 and U-2 are isopteropodine and pteropodine, respectively. These alkaloids have been previously isolated from several species of *Uncaria.* Further characterization studies on U-3 will be conducted in order to establish its identity.

ACKNOWLEDGMENT

The authors are grateful to the Medical Research Center, National Institute of Science and Technology for the facilities put at their disposal; to Dr. G. Wulff, University of Bonn, Germany for recording the spectra; to Professor Mamerto Sulit, retired professor, University of the Philippines, for collecting the plant material; and to Mr. Hermes Gutierrez, National Museum for identifying the plant material. The senior author wishes to acknowledge the financial assistance from the National Science Development Board — Special Science Fund. Technical assistance of Miss Edith Roque, Miss Elena Rigor, and Miss Norietta Carandang is being acknowledged.

PHYSIOLOGICAL RESPONSES OF RICE TO TCE-STYRENE*

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(Received for publication, April 15, 1974.)

ABSTRACT

The effects of TCE-Styrene on germination and subsequent growth, protein, amino acid, RNA, and starch contents together with amylase activity in rice were studied.

Rice was very susceptible to TCE-styrene at the very early stages of development but the susceptibility decreased as the seedling became older. The pronounced phytotoxic symptom was the failure of the primary leaf to break through the coleoptile. In such cases, the primary leaf became transparent and later brownish as contact with the herbicide was prolonged.

No considerable changes in the contents of protein, RNA, and amino acids were obtained. A slightly slower starch degradation was observed in the grain of the treated seedling which was not accompanied by an inhibition of α-amylase activity. Deseeded seedlings grown in solid White's medium which were likewise inhibited in growth by TCE-styrene suggests that the herbicide affects processes taking place in the developing plant rather than in the grain.

INTRODUCTION

TCE-styrene (α-2,2,2-trichloroethyl styrene) is a recommended pre-emergence selective herbicide for weed control in rice. The application of TCE-styrene at the rates of 1.0 and 2.2 kg per ha active ingredient gave excellent control of *Echinochloa crusgalli* resulting in rice grain yield increase of 5.5 tons per ha over the control.[1] However, very limited information is available on the basis for the selectivity of the herbicides and its physiological action. This study represents an initial attempt to elucidate the mode of action of TCE-styrene.

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* Central Experiment Station Contribution No. 73-39/. Portion of Ph.C. thesis in Agricultural Botany presented by the senior author; supported by Rockefeller Foundation.

** Research fellow, International Rice Research Institute College, Laguna, Philippines. To whom correspondence is to be directed.

Philipp. J. Sci., **103** (2), 1974: 81-89.

MATERIALS AND METHODS

Germination and treatment of seedlings. — Seeds of rice cv. IR-8 were sterilized with 5 per cent calcium hypochlorite solution for 10 minutes, washed repeatedly with tap water and soaked in distilled water for 24 hours. The soaked seeds were germinated on enamel trays lined with moist filter paper in the dark at 24°C. Uniform seedlings at the desired stage were treated with 50-ppm TCE-styrene solution in Petri dishes for 48 hours. Untreated seedlings were always maintained in all cases as checks. The concentration, 50 ppm, was found in preliminary tests to induce optimal response. In all determinations, three replications were provided for both control and treated sets of seedlings.

Determination of fresh weight, dry weight, protein content and starch content. — The roots, shoots and grains of 5-day-old seedlings from control and 48 hours treated lots of 5-day-old seedlings were collected separately and weighed immediately. For the dry weight, the tissues were dried at 80°C for 24 hours. Total protein was determined by the Kjeldahl method. The starch content was measured by the Anthrone method following the procedure of McCready *et al*,[2] as modified by Yoshida *et al.*[3] The absorbance at 630 mμ was read in a Bausch and Lomb Spectronic 20.

Determination of the amino acid composition and RNA content. — Shoots from control seedlings and 5-day-old seedlings treated with 50-ppm TCE-styrene at 3 days were collected and frozen immediately. The amino acids were isolated from these shoots following the procedure of Dunnill and Fowden[4] as modified by Lantican *et al.*[5] Ten lambda of the amino acid extract containing 30 mg of the original sample was run two-dimensionally on Whatman Filter Paper No. 1 with butanol-acetic acid-water (30:6:14) and phenol ethanol-water (3:1:1) as solvents. Ninhydrin was used to develop the spots. For the determination of total RNA in the shoot, the procedure of Cruz *et al.*[6] was followed using 500 shoots. The results were expressed in μg per mg tissue and μg per shoot.

Determination of α-amylase activity.—α-amylase was not tracted according to the method of Robles and Mercado[7] and its activity was assayed according to the procedure of Jones and Varner.[8] Whole seedlings were used as the source of the enzyme with 5 grams as the weight of the sample. The activity was expressed in μg per g per min.

Response of deseeded rice seedlings to TCE-styrene. — Grains were detached from 3-day-old plants and the deseeded seedlings were placed in 0.8-per cent solid agar medium, agar medium with 50-ppm TCE-styrene, White's culture medium alone, or White's culture medium with 50-ppm TCE-styrene. Increments in shoot and root lengths were taken after 48 hours together with the fresh weight.

RESULTS AND DISCUSSION

TCE-styrene did not inhibit the germination of rice but as soon as the coleoptile had emerged, the seedling became susceptible to the herbicides. As shown in Table 1, at the early stages of development the rice plant was more susceptible to TCE-styrene. During the third and fourth days (stages 3 and 4), the length of the coleoptile represented the shoot length. On the fifth day (stage 5), the increase in shoot length was due to the elongation of the primary leaf which has just broken through the coleoptile. The sensitivity to TCE-styrene decreased with age so that on the seventh day, there was very little inhibition of shoot elongation.

TABLE 1. — *Effect of TCE-styrene on shoot growth at different stages of development.*

Age at treatment (days after soaking)	Increase in length*		Difference
	untreated (mm)	treated (mm)	
3	9.0	5.4	3.6
4	10.1	4.9	5.2
5	11.9	6.0	5.9
6	13.0	8.7	4.3
7	11.0	10.1	0.9
8	9.3	8.0	1.3
9	9.3	7.9	1.4
10	9.2	7.8	1.4
11	11.8	10.6	1.2
12	6.8	5.9	0.9
13	4.6	3.8	0.8

*Average of three replications with 10 seedlings each.

In the sensitive stages, the pronounced phytotoxic symptom of TCE-styrene treatment is the failure of the primary leaf to break through the coleoptile (Plate 1, figs. 1 and 2). On prolonged treatment, the primary leaf, starting from the tip, became transparent and showed brownish discoloration of the primary leaf inside the coleoptile. These effects are similar to those observed with halogen-substituted benzoic acids.[9] These phytotoxic symptoms were apparent only at the early stages of seedling development. The suitability of TCE-styrene for use as herbicide in transplanted rice apparently lies in the observation that older rice seedlings have passed the critical stage of susceptibility.

The fresh and dry weight of the root and shoot as affected by TCE-styrene are presented in Table 2. Generally, treatment with herbicide lowered the fresh and dry weights of the root and shoot. Correspondingly, the treated seedlings had higher dry weight of the grain.

TABLE 2. — *Effect of TCE-styrene on the fresh weight and dry weight of rice seedlings.**

Treatment	Fresh Weight		Dry Weight*		
	Shoot (mg/tissue)	Root (mg/tissue)	Shoot (mg/tissue)	Root (mg/tissue)	Grain (mg/tissue)
Untreated	11.80	10.50	1.16	0.83	23.4
Treated	7.0	5.40	0.70	0.70	24.2
Per cent of untreated	59.3	60.3	60.2	84.3	103.4

*48-hour treatment on 3-day-old rice seedlings.
**Average of three replications of 30 seedlings each.

Starch breakdown is one of the major processes taking place in the germinating rice seed. At 3 days after soaking, when the coleoptile began to emerge, the starch content of the grain was reduced to 85 per cent (Table 3). At 5 days, it was

TABLE 3. — *Effect of TCE-styrene on starch content of the rice endosperm.*

Age of seedling	Starch content			
	Replication			
	I	II	III	Average
3 days old	87.5	83.5	85.0	85.3
5 days old (untreated)	68.0	66.0	80.0	71.1
5 days old	74.0	82.0	82.0	79.3
LSD* (15 per cent)				12.15

*Statistical analysis between the treated and untreated.

further reduced to 71 per cent. However, when the seedling was treated with TCE-styrene for 48 hours, starch degradation although statistically insignificant was consistently slower. Only a 6-per cent reduction occurred between 3 and 5 days after soaking compared to 14 per cent in the control. The slower degradation of starch in the treated seedling may account for the higher grain dry weight.

One process involved in growth is the synthesis of protein and RNA. However, in spite of the inhibited growth of the shoot, there was no change in the total protein content as measured by the total nitrogen in seedlings treated for 48 hours (Table 4). Table 5 shows the freeze-dried weight and the RNA content expressed in per tissue and per μg bases. The dry weight of both control and treated tissues approximated that obtained earlier with oven-dried tissue. The amount of RNA expressed in μg per mg of shoot was higher in the treated seed-

TABLE 4. — *Protein content of rice endosperm treated with TCE-styrene.**

Treatment	Protein content of endosperm (per cent)				Average
	Replication				
	I	II	III	IV	
Untreated	5.415	5.623	5.623	7.081	5.94
Treated	5.141	6.642	6.872	6.539	6.30
LSD (5 per cent)					1.43

*48-hour treatment on 3-day-old rice seedlings.

TABLE 5. — *Ribonucleic acid content of rice shoots treated with TCE-styrene.**

Treatment	Dry weight of shoot** (mg/shoot)	RNA content	
		μg/mg of shoot	μg/shoot
Untreated	1.29	5.63	7.29
Treated	0.85	7.36	6.26
Per cent increase or decrease of the untreated over treated	—34.3	+30.7	—14.2

*5-day-old rice seedling receiving 48 hours treatment at 3 days.
**Freeze-dried 36 hours, average of 500 shoots.

ling. However, based on the total RNA per shoot there seemed to be zero to very slight reduction in RNA in the treated seedling. This discrepancy can be explained by the inhibited growth of the treated seedling. With less growth there is less deposition of wall material and generally less synthesis of dry matter as shown by the lower dry weight. Thus, more RNA was obtained per mg dry matter. The values on RNA per shoot were considered the more valid representation as it permitted comparison based on the response of individual plant. A similar representation was used by Cruz *et al*,6) Lapade *et al*,10) and Robles and Mercado.7)

Paper chromatographic analysis of the amino acid composition revealed no modification in the kinds of amino acids detected. Eleven amino acids (histidine, aspartic acid, serine, glycine, asparagine, glutamic acid, alanine, methionine, valine, phenylalanine and leucine) were identified in treated and untreated shoots (Plate 2, figs. 3 and 4). However, the spots from the treated seedlings were somewhat less intense in reaction to ninhydrin. These observations suggest that TCE-styrene does not interfere with any major process in protein metabolism. These effects are similar to those induced by trifluralin in rice which causes a general decrease in amino acids5) but has no direct effect on protein synthesis.11)

Robles and Mercado2) have observed that amylase activity in rice increases steadily from the third to the sixth day of germination after which the activity decreases. The period of high amylase activity coincides with the period at which rice is very susceptible to TCE-styrene. Determination of the α-amylase activity in treated and control seedlings (Table 6) indicated

TABLE 6. — *α-amylase activity of rice seedlings treated and untreated with TCE-styrene.**

Age of seedling	Length of treatment (hr)	Amylase activity of intact seedling µg/g/min
Three days old	0	2.0
Five days old (untreated)	0	23.8
Five days old (treated)	48	21.6
LSD (10 per cent)		7.32
LSD** (5 per cent)		10.78

* TCE-styrene treatment for 48 hours on 3-day-old rice seedlings.
** Statistical analysis between the treated and the untreated.

no significant inhibition of amylase activity by TCE-styrene *in vitro*, ruling out any direct interference with the starch breakdown. When the seedlings were deseeded and supplied with White's medium, TCE-styrene caused similar growth inhibition as if the grain was intact (Table 7). These observations indicate that the herbicide affects a process or processes occurring in the developing plant rather than in the endosperm or grain. TCE-styrene may instead be acting on the utilization of metabolites coming from the breakdown of reserved materials in the endosperm.

TABLE 7. — *Response of deseeded rice seedlings to TCE-styrene.**

Medium	Length**		Fresh weight**	
	Shoot (cm)	Root (cm)	Shoot (μg)	Entire seedling (μg)
Distilled water	0.52	1.74	3.0	9.6
TCE-styrene	0.56	1.80	3.4	10.0
White's medium +TCE-styrene	0.78	1.78	6.0	13.6
White's medium	1.45	2.05	7.5	15.5
LSD (5 per cent)	0.108	0.121		
Intact plant in distilled water	1.70	4.00	10.00	22.4

* 48 hours treatment of 3-day-old rice seedlings.
** Average of 30 seedlings.

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The authors are grateful to Dr. Marcos R. Vega, assistant director, International Rice Research Institute, for his valuable comments and suggestions on the manuscript.

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ILLUSTRATIONS

Plate 1

Fig. 1. Five-day-old rice seedlings.

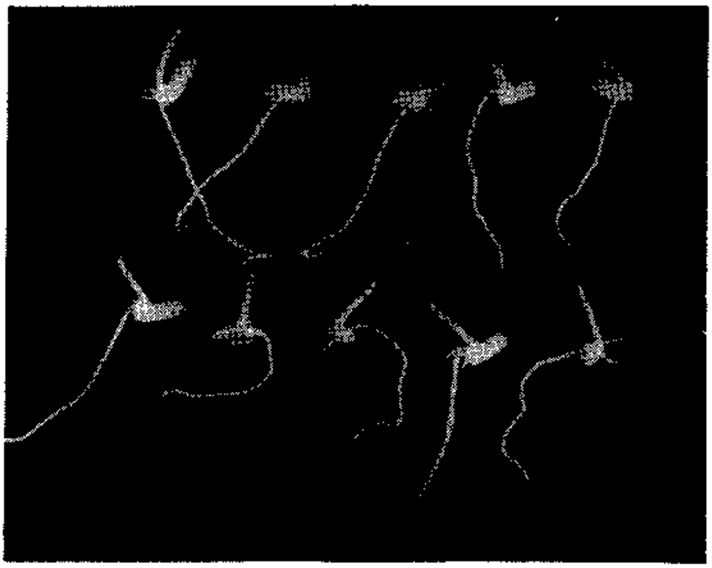
2. Five-day-old rice seedlings treated with TCE-styrene at 3-day stage.

Plate 2

Fig. 3. Paper chromatogram of the amino acids in the shoot of 5-day-old rice seedlings.

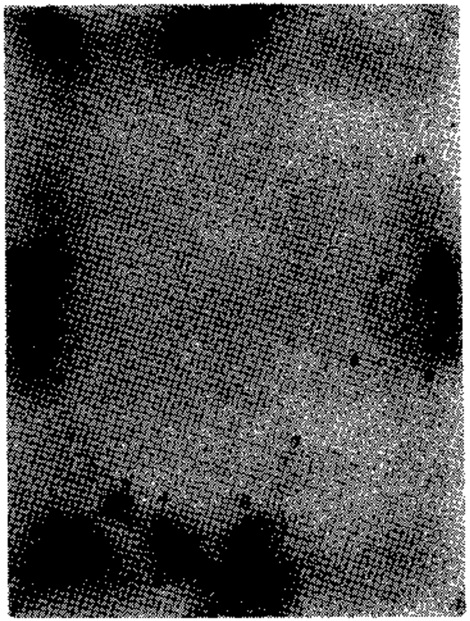
4. Paper chromatogram of the amino acids in the shoot of 3-day-old rice seedlings treated with TCE-styrene.

1



2

PLATE I.



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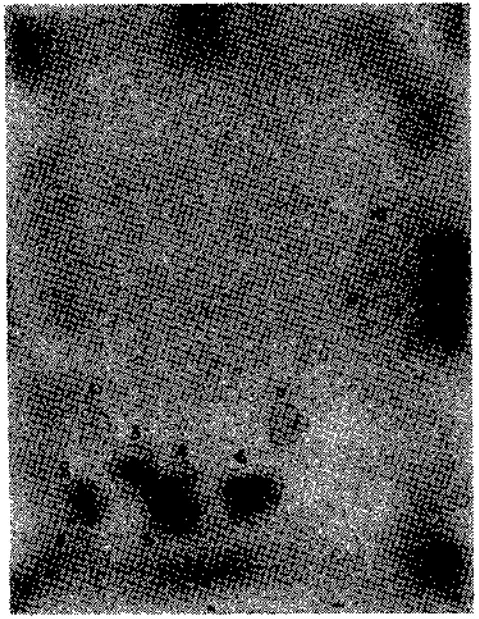

4

PLATE 2.

EFFECT OF TRIFLURALIN ON SUGARS IN RICE SEEDLINGS*

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ABSTRACT

Three-day-old rice seedlings were treated with 50-ppm trifluralin solution for 24 hours. Growth response in intact and deseeded seedlings, sugar content, and invertase activity were determined. Results showed that trifluralin induced growth inhibition in intact seedlings and deseeded seedlings provided with artificial medium. Qualitative analysis of sugars revealed the presence of glucose, fructose, and sucrose in the decapitated root and grain of the control. Treatment with trifluralin decreased sucrose to an undetectable level in the decapitated root with no change in the grain. Invertase activity was detected only at the root tip of both control and treated seedlings. An inhibited transport of metabolites in trifluralin-treated seedlings is considered a probable explanation to the physiological modifications induced by the herbicide.

The principal food reserve of the rice seed is starch stored in the endosperm. Starch is hydrolyzed to simple sugars such as glucose and is transported to the scutellum, where it is converted to sucrose.(1) Sucrose is then mobilized to the meristematic tissues where it is hydrolyzed to glucose and fructose.

One of the observed effects of trifluralin on rice is the decrease to undetectable levels of glucose and fructose at the root tip during susceptible stages.(2) Amylase activity can be enhanced by trifluralin but only on the fifth and sixth days from sowing.(3) In this study, the effect of trifluralin on sugars and sugar utilization is reexamined to determine more closely the effect of the herbicide on sugar distribution and utilization.

MATERIALS AND METHODS

Rice seeds var. IR-8 were germinated on enamel trays lined with moist filter paper and kept in the dark. Samples were taken after 72 hours and treated accordingly.

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Response of deseeded seedlings to trifluralin. — Three-day-old seedlings were separated from their residual endosperm or grain and transferred into Petri dishes containing either plain agar or solid White's medium with or without 50-ppm trifluralin solution. Ten seedlings were used for every treatment replicated thrice. Initial measurements of the root and shoot were taken. Observations were made after 24 hours taking note of the elongation of both organs and the presence of swollen meristematic tissues. Intact seedlings were grown and treated similarly for comparison.

Analysis of sugars. — Three-day-old seedlings were treated with 50-ppm trifluralin solution for 24 hours. After treatment, the radicle of each seedling minus 3 mm of its tip and the endosperm were collected, frozen, and analyzed for sugar content. The same parts of untreated set of seedlings were analyzed similarly.

Ten grams of each sample was ground in 70-per cent cent alcohol and the filtrate was passed through a column of Permutit Q to separate the amino acids. To eliminate organic acids, the effluent was filtered through Amberlite IRA-410. The final solution containing the free sugars was concentrated to 1 ml at 40°C. The concentrate was chromatographed on Whatman filter paper No. 1 using butanol:acetic acid:water (4:1:5) as the solvent. Detection of the reducing sugars was done by spraying the chromatogram with $AgNO_3:NH_3$ (1:1), while for the nonreducing sugars, TCA: Naphthoresorcinol (1:1) was used. The sugars were identified by comparing their Rf values with standard sugar solutions chromatographed and developed similarly as the plant extracts.

Extraction and assay of invertase activity. — Invertase was isolated according to the method of Ricardo and Rees.[4] Five grams fresh weight of the 3-mm root tips, the decapitated root, and the endosperm taken from treated and untreated seedlings were homogenized separately in citrate-phosphate buffer, pH 7.0, then filtered through Whatman filter paper No. 1. To the filtrate were added $(NH_4)_2SO_4$ crystals to precipitate the enzyme. The precipitate was dissolved in buffer and dialyzed for 24 hours against the same buffer at half-strength. The resulting dialyzate was used as the enzyme preparation.

For the assay, the reaction mixture consisted of 1.0-ml enzyme preparation and 4.0-ml citrate-phosphate buffer, pH 7.5, containing 50-mg sucrose. The mixture was incubated at 30°C for 2 hours. The reaction was stopped with 5.0 ml of 6.5-per cent $ZnSO_4$ and 5.0 ml saturated $Ba(OH)_2$ solution. The presence of reducing sugars was determined with dinitrosalicylic acid and the resulting deep red solution was read at 540 mμ.

RESULTS AND DISCUSSION

Intact plants treated with trifluralin manifest an inhibited elongation of the root and shoot together with swelling of the meristematic tissues.[5, 6, 7] Table 1 shows that deseeded rice seedlings provided with an artificial source of food materials still respond to trifluralin as shown by the inhibited elongation of the root. However, swelling of the root tip was not evident. As in previous studies, shoots were observed to be less sensitive to trifluralin than roots.[7]

TABLE 1. — *Growth increment of rice seedlings grown in vitro with or without trifluralin.*

Medium	Growth increment*	
	Root	Shoot
I. Intact seedling	*mm*	*mm*
Agar	17.60	9.16
Agar + Trifluralin	2.66	5.86
White	13.70	11.86
White + Trifluralin	2.43	9.26
II. Deseeded seedling		
Agar	1.30	1.36
Agar + Trifluralin	0.16	1.50
White	4.33	2.36
White + Trifluralin	0.43	2.26

* Average of three replications with 10 seedlings each.

The positive response of deseeded rice seedlings to trifluralin indicates that the primary phytotoxic action of trifluralin is in a process or processes occurring outside the endosperm; thus, ruling out amylase activity in the endosperm. The enhancing effect on amylase activity previously found[3] apparently represents a secondary effect of the herbicide. The absence of swelling in spite of the inhibited root elongation indicates that swelling takes place after growth inhibition has set in and probably, it is a result of the latter when further disruptions of normal metabolism in the endosperm has occurred.

A qualitative analysis of the sugars present at the decapitated root and the endosperm (Table 2) revealed the presence of glucose and fructose in these tissues of both treated and untreated seedlings. Sucrose was detected in the endosperm of both sets. It was also found in the decapitated root of the control seedling but not in the treated seedling.

TABLE 2. — *Sugars present in résidual endosperm or grain and the decapitated root of rice seedlings treated and untreated with trifluralin.*

Sugar	Decapitated root		Grain	
	Control	Treated	Control	Treated
Sucrose	+	–	+	+
Glucose	+	+	+	+
Fructose	+	+	+	+

The absence of sucrose in this particular tissue can not be attributed to the activity of invertase (Table 3). Since sucrose is the transport form of sugar, the failure to detect sucrose in this tissue suggests the possible interference of trifluralin in sugar transport. The glucose or fructose detected represents that translocated to the tissue before herbicide treatment.

TABLE 3. — *Invertase activity in rice seedlings treated and untreated with trifluralin.*

Tissue	Invertase activity	
	Control	Treated
Root tip	+	+
Decapitated root	–	–
Grain	–	–

Lapade and Mercado [8] reported a general decrease in amino acid content in the root tip of rice when treated with trifluralin. The change was more pronounced in early stages than at later stages of development. This decrease may be the result of inhibited sugar transport subsequently lowering the concentration of raw materials needed for amino acid synthesis. As the seedling becomes less dependent on the endosperm, the effect of trifluralin decreases. According to a report by Rogozinska *et al,*⁹⁾ a high invertase activity coincided with the region of cell elongation in maize. Thus, the lower invertase activity at the root tip of the trifluralin-treated seedling is reflected in the slight or complete absence of normal elongation process.

Further study on translocation and phloem differentiation as affected by trifluralin is being undertaken.

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THE ETHNOBOTANY OF THE TASADAY: THE USEFUL PLANTS[*]

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ABSTRACT

A general account of the Tasaday environment, with emphasis on the flora, is followed by an enumeration of the useful plants. The arrangement of the main data is based on the categories of uses for which plants are exploited — food, food acquisition, cordage, body adornment and care, stimulants, firewood, building materials and nonsubsistence uses, with suitable subdivisions. A list of the plant collection that was made in 1972, including the useful plants, forms an appendix to the paper.

The Tasaday domain, located at approximately 4,000 feet above sea level, is part of the great rainforest of South Cotabato. Seemingly impenetrable because of its dense vegetational cover and extremely dissected montane topography, the landscape is unrelieved by the plateaux and rolling plains that are occupied by the Tasaday's nearest neighbors, the Blit, Ubo and Tboli, who put such land to agricultural use. The intraforest difference in topography however, cannot be the principal reason for the absence of agriculture among the forest people, for many indigenous tribes in the Philippines practise subsistence farming on similar gradients, and often at equivalent altitudes.

Our cursory observations of the mountain soils, made during forays with our Tasaday hosts to dig the wild yam, *biking*, revealed media for plant growth not unlike the swidden soils of the neighboring groups. A surface leaf litter, varying in depth from 10 to 20 cm, covers a layer of dark-gray, heavily organic soil seldom penetrating more than 10 cm. The succeeding layer between 15 and 40 cm is generally a free-working, rather sandy textured material of yellow color interspersed with frequent white specks indicating a high limestone content. Soft gray stones, seemingly weathered, are occasionally encountered in both the gray and yellow layers described above. The layer basal to these, and into which the *biking* roots penetrate, is

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again yellow in color, but without the obvious signs of limestone, and compacted to a degree that is signalled in the increased effort of the harvester in the digging of the edible roots.

The soils of the narrow stream banks and terraces have little depth under the surface litter and dense herbaceous vegetation. A thin gray layer, seemingly rich in clay, surmounts a mixture of gray and yellow soil in a predominant medium of waterworn stones and boulders. These areas unmodified by man (e.g., by further terracing and the production of "artificial" soils) are less promising than the mountain slopes for agriculture: they do indicate limited but obvious changes of streamflow direction over time.

It may be suggested further that while the edaphic environment of the Tasaday would hardly be the subject for modern agricultural development, it is again not the primary limit on adoption of subsistence agriculture.

The impression of the climate from our visits and from comparison with observations of others (personal communications with Manuel Elizalde Jr., John Nance, Carlos Fernandez, and David Baradas) is that although the Tasaday area is subject to heavy rainfall, it conforms with the general typification of Cotabato climate by Hendry ¹⁾ — there is no pronounced seasonal characteristic in terms of rainfall or temperature. During our August 1972 visit, however, there was only two or three days of rain, a dry period noticed by the Tasaday, and probably a reflection of the abnormal drought in the southern Philippines while Luzon was suffering from heavy rains. Both rainfall and cold are disliked by the Tasaday. The occasional galelike winds that result in the uprooting of trees probably form the greatest single hazard to human life in the forest. Several times, the Tasaday pointed out to us the advantages of living in their caves as effective protection from the weather.

Fernandez and Lynch ²⁾ divide the environment of the Tasaday into three zones: I. The stream; II. Stream banks and terraces, from 1 to 25 feet above the water level; III. The upland forest. This provides a convenient classification of the resource areas exploited by the group in their hunting and gathering economy at present. Furthermore, a "negative" zone might be added — that portion of the forest extending from the cave-mouth downhill to the streambed. Here, the vegetation is protected from cutting and wilful damaging, for such action involves the threat of heavy rain and the threat of sickness to the perpetrator. The terrestrial sections of the environment, Zones II and III of Fernandez and Lynch, are differentiated by the physical properties of the soils; in our observations of the vegetation of Tasaday, there is further support for such zonation.

THE FOREST OF TASADAY

The rainforest of Tasaday exhibits, in general, the floristic complexity of the primary forest prevalent in the humid tropics. It is basically a dipterocarp forest dominated by the towering member species of the family Dipterocarpaceæ, particularly of the genera *Shorea* and *Vatica*, together with some species of the genus *Lithocarpus* of the family Fagaceæ which attain similar stature, forming the highest canopy in a typically three story forest cover. It is interesting to note that the upper altitudinal limits of the dipterocarp forests of the Philippines, and particularly Luzon, reported by Brown and Matthews 3) and Merrill 4) as thriving in the lowlands to about 3,000 feet, are exceeded in the Tasaday forest. Even in Mindanao, the recent work of Kellman 5) indicates the presence of this Dipterocarpaceæ-Fagaceæ association, or the zone transitional towards oak forest, at a considerably lower level.

Immediately below the dominant canopy, medium-sized trees occupy the second story of the forest cover. Prominent in this layer are species belonging to the genera *Dillenia, Lithocarpus, Palaquium, Goniothalamus* and many others. Equally conspicuous and competing in height in this canopy are individuals of a species of *Caryota* palm. It is not unlikely, however, that some species of the genus *Lithocarpus* will emerge beyond this layer when mature.

The component elements of the third layer are represented by numerous species of small trees and some species of palms and tree-ferns. Noteworthy among the genera are *Aglaia, Clethra, Aralia, Glochidion*, and *Ficus* particularly along the river, and many other small trees as well as emergent young plants of big trees. Of the palms, the genera *Areca* and *Pinanga* are common, with some species of the tree-fern *Cyathea*. The genus *Pandanus* is also conspicuously represented in this layer by an unnamed species of branching habit, with individual specimens up to 7 m in height.

Of the numerous species of vines that represent a characteristic feature of the vegetation, there are at least four genera of the large climbers such as *Dinochloa, Calamus, Daemonorops* and *Freycinetia* whose prominence and abundance overwhelm the presence of other groups of plants in this category. The genus *Dioscorea*, for instance, which is a very important source of food of the Tasaday, is abundant in the area but it is difficult to find without the trained eye of the native. Epiphytes such as orchids, ferns and some urticaceous species are equally numerous.

The floor of the forest is relatively clear except in places where the sun can penetrate, small areas where the ground is thickly covered by numerous species of terrestrial herbs, shrubs and small trees, especially along the streams. Epiphytes and vines are numerous and there is also an abundant growth of fern species in the numerous and small valleylike formations in the forest. Mosses, though a prominent component of the vegetation, show some kind of host preference in their uneven distribution.

This has been a general descriptioon of that part of the Tasaday forest that Fernandez and Lynch [2] have called "the upland forest" or Zone III. There are, however, three examples of plant associations that deviate from the described pattern. On the mountain facing the Tasaday caves to the east, that on foot is about 15 to 20 minutes away, two adjacent sites have been cleared for landing by the PANAMIN helicopter. The recent occurrence of significant outside contact appears to be borne out here by the invasion of volunteer species limited to these clearings. The incidence of young plants of second growth trees of the genera *Homalanthus* and *Macaranga*, and a small but almost pure stand of the herbaceous *Erechtites* are indicative of accidental dispersal by visitors from Tboli and Blit. From this vantage point, one of the few from which the forest may be viewed from the ground, two other vegetation types are observable. Both are to the southwest, on the mountain slopes across the stream (and on the same side as the caves). Here there is a tract of mixed species second growth (Plate 1), and a large, nearly pure stand of *Casuarina rumphiana*, the graceful, pinelike tree, extending from near the stream (seemingly the species' normal habitat), almost to the summit at an estimated 5,000 feet above sea level. These associations as breaks in the normal landscape of the climax forest present an aspect somewhat similar to varying stages of recovery after swidden farming, but the Tasaday offered a contrary explanation. They said that these areas were formerly exposed by landslides occasioned by heavy rains. While we did not reach these areas in our field work, we did encounter several lesser examples of landslide in such cases as typified by low vegetation of grasses and shubby growth, and examples of seedling *Casuarina* are often noted.

The edge of the forest along the river is probably the richest in terms of species. This is the area that Fernandez and Lynch [2] noted as Zone II. On both sides of the river, the ground is thickly populated by terrestrial herbs belonging to various families such as Zingiberaceæ, Araceæ, Marantaceæ, Amaryllidaceæ (particularly *Curculigo capitulata*), Cyperaceæ, Gramineæ, Liliaceæ, Begoniaceæ, Balsaminaceæ, Labiatæ, Chloranthaceæ, as well as herbaceous species of Leguminosæ, Urticaceæ, Rubiaceæ and other families. The ferns in this area are also abundant and numerous, not only in number but also in kind. The families that are prominently represented by numerous species of shrubs are Boraginaceæ, Melastomataceæ, Saurauiaceæ, Verbenaceæ, Vitaceæ, and Rubiaceæ. Among the small trees, the most prominent are represented by many species of the genus *Ficus*, some of which grow as high as 10 meters. There are also members of the genera *Aralia, Dendrocnide, Abarema, Leea,* and *Casuarina rumphiana*. Some individuals of the genus *Pandanus* also constitute a conspicuous element of the vegetation in this particular habitat, and among the palms, the most numerous are seedling plants of *Caryota* and species of *Areca*. The vines most commonly encountered here belong to the genus *Piper*. On the islandlike habitats formed by the division of the main stream or the confluence with its tributaries, the vegetation is virtually dominated by zingiberaceous species, *Curculigo, Tricyrtis* and grasses of the genera *Setaria* and *Miscanthus*. Some dipterocarps and fagaceous trees were recorded on the stream banks, so that Zone II in vegetational composition resembles the same general rainforest type as Zone III, but enriched in species due to its comparative openness to sunlight and constantly higher water status.

PLANT COLLECTION

Field collection of herbarium specimens was aimed towards all the plants in flower and fruit, but where economic importance had been predetermined, sterile specimens were collected when fertile examples could not be found by us or our Tasaday informants. It may be seen from the plant list comprising Appendix 1 that many specimens have not yet been determined to the species level; these are the subject of further study at the Herbarium of the National Museum, Manila. Although the collecting of Tasaday plants is far from complete, several specimens suggest that this region of Cotabato may be the source of new species, or at least of species unrecorded in the Philippines to date. For example, St. John (personal communication), the expert on Pandanaceæ, has determined that two of the representatives of the genus *Pandamus* in Tasaday (Phil. Nat. Herb. 108863 and 108911) are recorded for the first time. Further, the liliaceous genus *Tricyrtis* (PNH 108822) is a primary recording for the country, while the form of *Tournefortia* (PNH 108881) may be a further new species. The problems of identification are further noted in the account of the following useful plants of the Tasaday.

THE USEFUL PLANTS

The ethnobotanical data are organized into eight major classes of the use of plants by the Tasaday, with subgrouping within these classes where appropriate. Table 1 shows the arrangement, together with the number of plants species involved in each category. Many species, however, are of multiple utility, and this is indicated in the individual treatments by reference to other categories in the enumeration. This may be exemplified by the *Caryota* palm, *basag*, first occurring under the major class A (Food Plants), subgroup (i) as a starchy food. Here it is annotated by "A(ii), B(ii), G," showing that basag is to appear further in the enumeration under the three respective categories of leaf and leaf bud food, used for faunal gathering and building material.

A. **Food Plants:**

(i) Starchy

Of the five plants in this category, one is a palm yielding a sago-like product—*natək* from the inner pith of the trunk, and four tuber-producing vines.

basag PALMÆ A(ii); B(ii); G

A genus of Palmæ known as the "Fish-tail Palm" is widespread in Southeast Asia, extending to India and Northern Australia: *Caryota cumingi* is used by the forest people of South Cotabato as a source of sago starch, *natək;* this process is said to have an innovative introduction to the Tasaday by Dafal. Other species of *Caryota, Corypha, Arenga* and *Metroxylon* yield forms of starch made by indigenous people of the Philippines.[6]

Basag palms are generally distributed throughout the Tasaday domain, but it was noted during our visit that on the stream and tributary vicinities, only seedling plants occurred; the more mature palms, prospects for food in the immediate future, are located in the upper forest sections. On the summits, however, the incidence of very few palms indicate that 5,000 feet is the upper limit of adaptation for *Caryota.* This production of *natək* from *basag* has been described and illustrated by Fernandez and Lynch.[2] Essentially similar to the process practised in Oceania on the true sago palms of *Metroxylon* spp., the toolage differs somewhat[7] as does the subsequent treatment of the starchy extract. While Oceanians often store the partially or fully dried starch for future use, Tasaday practice is to cook the starch in the extraction trough (see B(iii)) after decanting. The cooked product consists of two portions—a gelatinous covering layer called *lunana* eaten immediately by the group working on the site of manufacture, and the starch or *kəle natək* itself, often divided on the site prior to carrying back to the caves for more formal sharing with families unrepresented.

The *natək* is usually eaten with only partial reheating of the leaf-covered bundle by the individual family groups. It is the only plant commodity observed to be stored by the Tasaday; witnessed were bundles that had been held for about one week suspended at the individual hearths, but informants stated that when an excellent harvest occurs—where a palm needs several days to process or where separate parties bring in harvests simultaneously—storage may be effected in a small unoccupied cave quite close to the main Tasaday caves. Long-lasting qualities of *natək* are recognized, but during our visits, no substantial caches were observed.

Natək now not only seems to share with biking a dominant place in the starchy food sector of the Tasaday diet, but it also seems to enjoy a taste preference in the small society.

banag limukan DIOSCOREACEÆ

This wild yam species has been identified as *Dioscorea nummularia*. Burkill[8] recognizes this species' wide distribution in Southeast Asia, but its identification is at odds with the species identified as *D. nummularia* in Oceania.[9] Common in the Tasaday upland, it is noticeably most frequent close to the mountain summits, climbing to the upper canopy on trees of *Lithocarpus* and *Vatica*. As such, its presence would be difficult to detect were it not for the heavy scent of the prolific, multiple raceme flowers.

The tubers of *banag limukan (limukan* = "pigeon") are rarely sought, because of the lesser preference of taste in comparison with *biking* and the difficulty of extracting the deep and widely set tubers (often more than one per plant) from the soil. When gathered, the tubers are always cooked in the manner of biking (see below).

biking DIOSCOREACEÆ

Identity of this wild yam is uncertain, since no flowering or fruiting material was found during plant collection (a common occurrence with *Dioscorea*) in July, August, and December, 1972. Tasaday informants, also unsuccessful in finding fertile specimens, said that young yam plants, *dəmuliq bunga biking* sprang from the fruits, *bunga*. Two varieties are recognized—*biking ətaw* (with white-fleshed tubers) and *biking usa* (red-fleshed). The vegetative characters of the collected specimens do not conform with those of the wild yams of wild or cultivated *Dioscorea* of the Philippines. Our preliminary determination of *biking* as *D. luzonensis* Schauer, a wild edible yam occurring the lowlands of Luzon and described by Burkill,[8] Brown,[6] and Wester,[10] did not withstand the test of comparison with specimens of that species held in the Herbarium of the National Museum.

Distribution of *biking* is general through the Tasaday forest, but plants are rather uncommonly encountered in the vicinity of the stream. This is somewhat contrary to the observation of Fernandez and Lynch,[2] who record, in Zone II, that "Fernandez counted eight recently dug *biking* holes in an area

50-meter square." While this does not necessarily mean that all eight tubers were harvested simultaneously, such density was uncommon in our experience, and anything approaching it was observed in the upland forest. Within a radius of 2 km of the caves, harvestable plants were scarce during our visits.

This tuber is one of the principal foods of the Tasaday, reputedly the staple in the diet before the advent of Dafal. Difficult to harvest because of the depth to which the tuber grows into the soil substratum, the single tuber per plant, usually broken into sections as it is extracted from the ground, provides little bulk food for the amount of labor expended on its digging. A long tuber is never completely harvested because of the depth of its lower extremity. The largest specimen harvested during our field work, in August, 1972, was only 4.5 cm in its maximum thickness, and measured 170 cm in length. Regarded by the Tasaday as an excellent specimen, the total weight of the yam was only 1.5 kg, and its harvesting occupied a man and his waiting wife more than 50 minutes. Plate 1, fig. 1 shows Balayem, a Tasaday, digging a much smaller *biking*.

Harvested roots are usually taken back to the cave, and the day's harvest is pooled for division. The largest harvest seen by us consisted three roots whose total weight could not have exceeded 2 kg. The yams are prepared for consumption by wrapping in leaves and roasting; cutting into smaller chunks and stuffing into bamboo tubes with crabs or tadpoles, and steam-roasting on the fire. They may also be eaten raw, a practice generally indulged in outside the cave, as snack on the more distant forays from the cave.

məbanal DIOSCOREACEÆ

The identity of this species is determined as *Dioscorea divaricata*, a wild yam found in the lowland forests of Luzon and the Visayas.[8, 6, 10] Again, no fertile specimens were found in the Tasaday forest, so that identification was based on vegetative characters. The Tasaday distinguish *məbanal* from *biking* by its sparsely spined but otherwise similar climbing stems.

The distribution range of *məbanal* in Tasaday parallels that of *biking*, being noticeably less numerous, however. This is probably the main reason for its lesser importance in the diet. Fernandez and Lynch[2], reported that they knew of only one *Dioscorea* yam eaten, *biking*, but the difficulties in harvesting may be another factor. Of the two plants harvested in August 1972, the tubers were set some 50 cm under the ground in contrast to *biking,* in which the edible portions were evident just below soil surface. Our informants stated that it was possible to find *məbanal* tubers as large as those of *biking,* and there seemed to be no taste preferences between them, consumption methods being the same.

mələbanal LILIACEÆ

A climbing plant with similar growth habit and vegetative characteristics to *Dioscorea,* the identification of this plant is based on floral parts, as *Smilax china,* a plant of wide Southeast Asian distribution. There appears to be some relationship in the vernacular names as recorded for the tuberous plants supplementary to *biking* in the Tasaday diet — *banal, banag.* Burkill [11] records a possible Southeast Asian cognate from Sakai, *banar,* a name for "quite different plants," *Dioscorea pyrifolia* and unidentified species of apparently tuberous *Smilax.*

Both of the identified species of *Smilax* are found generally in the Tasaday forest, among other representative of the genus, not flowering at the time of our visits. Tubers of *mələbanal* are rarely eaten, and then always cooked. Their inferior taste is said to be the reason for their infrequent gathering. Tubers of *Smilax* sp. are commonly used as medicines among indigenous peoples of Southeast Asia and like some Dioscoreas are sources of saponins. However, Burkill [11] records one species, S. *megacarpa* DC. used by the Jekuns of the Malay Peninsula as food, among the Malay names for this species are *akar banar* and *akar rebanar (akar* = 'climber').

(ii) Leaves and Leaf Buds

There is a surprisingly low number of leafy vegetables recorded as being gathered by the Tasaday. It is not that such plants are absent from the forest; *Ficus, Alocasia, Begonia, Lactuca, Elatostema* are among the genera thus exploited as gathered dietary supplements among agricultural groups in Oceania and Southeast Asia. In fact, some of the species found in Tasaday are recorded by Brown [6] as food plants among other indigenous groups of the Philippines. Leaf buds, however, are common foods, [12] all derived from the various palm species of wide distribution in the Tasaday domain, and classed under the general category of *ubod.* Before these are discussed, the few leaf vegetables will be enumerated:

fesəw ARACEÆ A(iii)

Schismatoglottis calyptrata is a large herb commonly found throughout Southeast Asia, occupying comparatively damp forest sites as clumps of vegetatively reproduced plants. In Tasaday, it is found in the vicinity of the stream banks and damp fissures with intermittent flows leading to the main stream. Not recorded as a Philippine food-plant, it is here gathered occasionally in the form of young leaves (and flower buds when available) to cook with meat, *ubod* and other foods at the caves. In Java, Burkill[11] notes the species as a food plant gathered for its leaves and roots. We did not witness the consumption of this vegetable, but its gathering was evidenced by the depleted leaves when collecting botanical specimens of the plant.

kifuloq POLYPODIACEÆ

A fern of the genus *Microsorium*, the undetermined species is found on the stream banks. The young shoots are plucked from rhizomes and from the tips of young leaves, eaten raw as a snack or sometimes gathered for cooking like *fusəw.* We did not record such use for many ferns, but we suspect that more species are used in this way.

sukulab ubal POLYPODIACEÆ

The epiphytic fern *Asplenium nidus* is a common species in forests of the tropical Pacific. Found generally in the Tasaday forest, its utilization as food is questionable (not recorded during identification of specimens). The basis for its enumeration is on several recordings on incidental plucking and chewing of the tip of the broad leaves by children climbing host trees for other reasons. *Asplenium* leaf tips as a vegetable have been occasionally recorded in Melanesia and Polynesia (Yen, field notes of 1958-1971).

All of the forms of *ubod* are lengths of the growing points or shoots of Palmæ. The edible portions are the inner tissues, meristematic or at an early stage of differentiation. Brown and Merrill[3] note the use of this food over a large number of Philippine localities, incidentally with the same word for the food. The palms producing *ubod* may be divided into two growth forms, the familiar free-standing and erect types and the rattans, all here identified as species of *Calamus*, whose climbing stems rely on forest trees for support. It should be pointed out that the use of the shoot portions of the larger palms as food among the Tasaday does not include the top or emergent leaves, corresponding to the "millionaire's salad" of European-adapted cuisine in the tropics. Here, these young leaves are discarded, left lying with the other trimmings at the gathering site. Occasionally, we (the investigators) would gather such day-old remains as our own food.

basag PALMÆ

Caryota cumingii, the provider of *natək*, has a further importance as the source of the largest form of *ubod*. There is somewhat of a misnomer in the inclusion of the species as a leaf bud vegetable, for the greater part of the harvested sections of this *ubod* is probably some form of starch, the precursor to the inner *natək*-bearing inner pith rather than the leaf primordia. Sections of the upper stem are cut from young trees and trimmed by topping and removal of the outer sheath to a length varying from 1 to 2 m, depending on the age of the palm and the amount of *ubod* contained. Edible, raw or cooked, the prepared section is generally carried to the caves (Plate 1, fig. 2), where the vegetable is excised for division. Cooking may be effected in bamboo tubes or in leaf bundles, often mixed with available meat or tadpoles, small fish or crabs from the stream. The taste of *ubod basag* is rather bland, but this is no obstacle to the product being one of the popular Tasaday foods.

buluhəl PALMÆ B(iv); E; G

An unidentified *Areca* plam with small fruits, its main use is as food. The section of this shoot cut for *ubod* is a maximum of 100 cm in length, and quite narrow. Usually a part of a harvest of several kinds of shoots, all are taken back to the caves for cooking on one fire (two if the harvest is large, or if several people have brought in *ubod*) prior to division, cf. *ubod basag.*

Soon as the outer sheath is removed after cooking, the cylindrical form of folded, pre-emergent leaves is distinctly discernible. This also refers to the other forms of *ubod* enumerated in the following. The taste again, is bland.

kohan PALMÆ E

Areca caliso is the main nut for betel-chewing, but also sought after for *ubod.* The edible portion, considerably larger than *ubod buluhəl,* yields much less than *ubod basag,* and is again leafy, although sometimes rather pithy, with a bitter flavor.

ləfunuq PALMÆ A(iii); C

An unidentified *Calamus* rattan, its *ubod* is similar to all of the *Calamus* types, narrow (approximately (3½ cm maximum diameter) and cut to lengths seldom exceeding 40 cm. These sections are trimmed by removing the external spines and transported to the caves for cooking. Sometimes eaten raw, this ubod, like all of the rattan forms, is bitter in taste, resembling the popular Philippine vegetable, the fruit of the bitter melon, *Momordica charantia.*

Other forms of *ubod* are gathered from the following:

maganaw *Pinanga maculata*	PALMÆ	E
salangay *Calamus mindorensis*	PALMÆ	A(iii); B(i); B(iv); C
sufini/sufing *Calamus ornatus*	PALMÆ	A(iii); C; D(i)
tagisi *Heterospathe* sp.	PALMÆ	B(i); B(ii); B(iv); E

(iii) Flowers and Fruits

Of the 31 plant forms recorded for this category in Table 2, most are found in the varied vegetation of the riverine forest. The notable exceptions are the rattans, *ləfunuq, salanay* and *sufing* of the genus *Calamus* of climbing palms and *mata usa,* the only nut found so far in the Tasaday food-plant roster. The flowers and fruits are generally consumed raw as snacks, and the greater number are designated by the Tasaday as childrens' food. Fruits of Zingiberaceæ, seedy and only somewhat sweet and the rattans, all with sour edible arils and quite large seeds that are discarded, may be observed being carried back to the caves together with *ubod* or *biking,* and their exocarps are prominent feature in the cave floor litter. These, and the occasional large fleshy fruits of *syal dakal (Dillenia)* brought home by children, did not constitute any part of the main, more formal meals that were observed. The exception was the aroid *fusəw,* whose flower buds are plucked with the young leaves for cooking (see A(ii). We witnessed the casual consumption of most of these flowers and fruits during gathering forays at the stream and upper forest, but we are convinced that Table 2 is an incomplete recording of the edible species in this category. As food, no single species appears to be important in the Tasaday diet, but together, the category probably forms a significant component of the intake, particularly of children.

(iv) Fungus

The edibility of the fungi was not observed at first hand, other than a demonstration by one of the Tasaday that *kulot tuliyo* was harmless when eaten raw, compared with *kulot bigtalas,* regarded to be poisonous. Two others, *kulot batang* and *kulot maya,* were allowed as possibly suitable to eat, but only two were said to be purposely gathered for cooking at the caves, either heated on fires in *ləkək*-leaf wrapping, or incorporated with stream fauna in bamboo tubes:

kulot ubal POLYPORACEÆ

A species of *Daedalea,* gathered from fallen, rotted tree trunks.

kulot tanguluq AURICULARIACEÆ

Auricularia auricula-judae, found similarly, but sometimes on standing moss covered trees.

(v) Resins and Gums

Spontaneous exudates from tree trunks are found in a number of species in the Tasaday domain. The chewy, gum-like exudates of the riverine *Ficus,* however, are not used by the group. There are three species of the upper forest, whose resins and gums are consumed as snack-foods during hunting and gathering expeditions. None were recorded as brought back to the caves. The induction of exudation by slashing trunks with steel blades was demonstrated to us. Three of the large tree species were subject to this utilization:

mangəbə DIPTEROCARPACEÆ F

A thick fluid when flowing from the trunk of the *Vatica* tree, this resin is eaten when dry, being crisp, and rather tasteless except for a faint aroma.

mata usá BURSERACEÆ A(iii); B(iv); F

Another resin from *Chisocheton,* it is somewhat softer than that from *mangəbə* with a more penetrating odor, but it is the longer exposed, hardened portions that are selected for consumption.

mələfakid SAPOTACEÆ A(iii); D

Palaquium trees are found quite close to the river and well into the upland forest. Their exudate is considerably gummier than the two resins recorded above, and quite tasteless.

B. Food acquisition association:

(i) Plant Gathering

There are few tools connected with plant-food gathering as we observed in 1972. The *bolo* or steel knife has been adopted as an all-purpose implement.

salanay PALMÆ A(ii); A(iii); B(ii); C

Calamus mindorensis canes were observed twice as the material for hafting of traditional stone tools in demonstrations of the technique by the Tasaday, Mahayag. The thicker, split stems formed the handle, bound with pared strips of the thinner stems. Other rattans may be used for this purpose.

tagisi PALMÆ A(ii); B(iv); B(vi); E

The digging stick for harvesting of *biking* and other roots, *kali biking* is fashioned from the split stem sections of *Heterospathe*. This unidentified species apparently yields material of the correct rigidity for its purpose, but any "wooden stick" may be used. Cut to a length of approximately 1 meter and 4 to 6 cm wide, the simple tool is trimmed to an obtuse point. After use, it is discarded. The traditional digging stick, also *kadli biking*, is said to have been from deer horns, semipermanent and stored in the caves.

timlas EUPHORBIACEÆ F

A substitute material for *Heterospathe* as a digging tool is *Antidesma cumingii*, an unrelated species with tough stemwood.

(ii) Faunal Gathering

With the gathering of animals (as opposed to trapping or hunting), there is again little in the way of equipment. Stream gathering is largely a barehanded activity.

amutmagiso LILIACEÆ A(iii)

The juice from the broken lower leaf and flower of a species of *Tricyrtis* is rubbed on the hands preparatory to frog-catching. This is said to be attractive to the quarry. The flowers are also eaten by the Tasaday.

basag PALMÆ A(i); A(ii); G

The Caryota palm, when felled for *natək* is cut into sections for transport to the nearest water source. The trunk that remains is left for infestation by the palm weevil, *ləbutad,* a prized food gathered by the Tasaday. There appears to be a husbanding of this resource, in that not all of the *natək*-yielding section of the trunk is removed. The Tasaday are fully aware that this will be the site of infestation by *ləbutad,* and they will return at the appropriate times to collect the large larvæ. These may be cooked in leaves, or roasted on bamboo skewers.

məglungən ZINGIBERACEÆ A(iii); B(vi)

The leaves of *Alpinia* are most commonly shaped into cone-like containers for gathered stream products — tadpoles, fish, crabs, as well as *ləbutad.*

tagisi PALMÆ A(ii); B(i); B(vi); E

The digging stick, *kali biking,* may be used to pry apart the partially rotten trunks of Carpota in the quest for *ləbutad,* but again, any wooden stick of sufficient strength is said to be satisfactory.

(iii) Natək Production

The *natək* press thin[2]) is constructed of a variety and seemingly optional woods, dictated more by the convenience of trees of the right size than species. However, there are some components of this equipment with reasonable specificity.

anafa POLYPODIACEÆ (fern)

The leaves of a *Dryopteris* are among the leaf-lining species of the main part of the press (*gunaqan*), the enclosed platform on which the shredded *basag* pith is placed before treading the wetted material by the operator. The leaves act as a strainer, and are changed periodically during the process of extraction of starch.

anafa mahagtaw CYATHACEÆ (fern) G

Cyathea is also found among the leaf component of the "strainer" in the *natək*-making equipment, but the main use of the whole fronds of this tree fern is as a cover for the expressed starch, during decanting and awaiting the conclusion of the day's work and cooking of the product. This cover protects the raw *natək* from the instrusion of falling leaves of the surrounding forest and the flying material of the ongoing preparation of the raw pith nearby; its open nature may have some function, for the oxidation of the white pith signified by increasing reddening of the material as it goes through the manufacturing steps remains unimpeded.

anutung diqisak POLYPODIACEÆ (fern)

Another "strainer" component species is *Didymochlaena truncatula,* also cut for ground cover spread over the site chosen for the *natək* process.

balagilan URTICACEÆ A(iii); C; F

The bark of *Leucosyke capitellata* is easily stripped whole from a felled section of the tree. Two of these troughs are generally attached to the extraction platform, led into by banana or bamboo stem sections, also troughlike and placed immediately under the platform. As the *balagilan* troughs are judged to be at capacity, they are replaced. The *natək* is decanted and cooked in this container.

buluhəl PALMÆ A(ii); E; G

Leaves of this *Areca* sp. are considered the main palm leaf to be mixed with fern leaves to form the strainer, but other genera were observed on occasion, e.g., *Heterospathe.*

kayu səbang ARALIACEÆ

The thin straight stems of *Boerlagiondendron* were claimed to be the best material for the short (up to 60 cm) props of the natək troughs. Again there were many optional alternative materials for such props.

nafnaf GRAMINEÆ B(iv); B(vi)

Strips of this large species of climbing bamboo *Dinochloa luconiae* form the floor of the platform on which the starch is expressed; approximately 4 cm in width and 50 cm in length, these are tied to the lower part of the frame convex (outer) surface up to form a draining surface through which the water clouded with the pink-colored starch may run. An alternative for this material is said to be strips of *Areca* palm stem.

nafnaf usa GRAMINEÆ B(iv); H(iii)

A whole stem section of this smaller *Dinochloa* sp. is fashioned into a hammer head about 50 cm long, for the extraction of the inner pith of *basag*.

nənang ARALIACEÆ

The stem of *Schefflera* is said to provide the best handle for the *natək* hammer, *sakul*, because of its springiness. The head is lashed on with rattan.

(iv) Trapping and Hunting Equipment

This must be considered to be a partial list of materials used for trapping and hunting. There seem to be a large number of alternatives in the range, only some of which have been noted in field work.

agsamtukubung GLEICHENIACEÆ (fern)

The tough stems of *Dicranopteris linearis* are the best of the materials for tying heads to arrows.

bəlatakan ACTINIDIACEÆ

The springy, robust stems of *Saurauia elegans* is used as the spring for a wide range of traps, including the *bəlatik*, which seems to be the derivation of the name of the tree.

bəli taqog RUBIACEÆ F

Ixora bartlingii is a hardwood tree whose branches provide excellent springs for larger traps.

bukal tuduk RUBIACEÆ

Identified as the same species as *bəli taqog* this tree was differentiated by Tasaday and T'boli informants in name and function. This *Ixora* is the source for the finer springs of bird and rat traps.

budakan RUBIACEÆ F

Psychotria luconiensis provides springs for many kinds of traps.

falawan/kətalunan GRAMINEÆ

The straight flowering stems of *Miscanthus floridulus,* clumps of which are found in open areas of the stream area, are used for making arrows. Apart from children's toys made from *nafnaf usa,* no bows are known to have been made by the Tasaday.

gwalad biku RANUNCULACEÆ

The climbing stems of *Clematis javana* are used as the cords and trip loops of bird traps and also as nooses for monkey traps.

kalawan səfet CUCURBITACEÆ

The vines of *Melothria mucronata* are used in monkey, bird and rat traps as trip and noose.

kəlinga wayug MYRSINACEÆ

This species of *Maesa* is the source of trip lines for the *balatik,* the strong vine releasing the lethal bamboo *(nafnaf)* spears which impale deer.

kəsisang ubal VITACEÆ

The stems of the vine *Cissus assamica,* although distinctly jointed, are used as cordage in a number of traps, to which separate nooses are attached.

mata usa BURSERACEÆ A(iii); A(v); F

The young saplings of this unidentified species of *Chisocheton* form the springs of small traps.

nafnaf GRAMINEÆ B(iii); B(vi)

The sharp spears of the deer trap, *bəlatik* are formed from split sections of this large *Dinochloa* bamboo.

salanay PALMÆ A(ii); A(iii); B(i); C

Many of the trip strings of small traps are made from this rattan. Other rattans, however, appear to be used. Long lengths of rattan are often transported to the caves to make strings, especially for traps.

səmuuhuh CASUARINACEÆ F

The young saplings and branches of *Casuarina rumphiana* are used for *bəlatik* springs, but with surprising infrequency, considering their toughness, straightness, and availability.

tungaw MELASTOMATACEÆ F

Fine stems of *Astronia subcaudata* are used as springs in small traps.

(v) Bait

Trapping, purportedly taught to the Tasaday by Dafal in recent years, appears to be of two types: the unbaited *balatik* or spear trap, whose action of impaling the larger forest mammals, deer and pig, relies on the tripping of a camouflaged cord by the animal; and the small baited noose traps for smaller animals and birds. In soliciting information on baiting of the latter, we obtained a considerable plant list, but many of the fruits mentioned were those edible to humans and were more concerned with bow and arrow hunting (also an innovation); they were more indications of the kinds of trees on which monkeys, marsupials and birds could be cornered for shooting. In the accompanying of the Tasaday during their inspections of the small traps, baiting seemed to be a secondary consideration to the checking of structures and the tripping mechanism. Often there was no sign of bait in the reset traps, for which no satisfactory reason was forthcoming from informants. Table 3 is a list of the fruit species said to be definitely used as trap baits.

(vi) Wrapping and Food Preparation

While the following are the plants most commonly used in food wrapping and preparation, there are undoubtedly others used as a matter of convenience. This is particularly so in the upper forest, where the herbaceous Marantaceæ, Zingiberaceæ and ferns are generally absent.

kataqas ARACEÆ

The large leaves of *Homalomena* are commonly used as food wrappers, but appear to be secondary to *ləkek* (below). They seem to function more as food plates than as a "utensil" for cooking.

ləkek MARANTACEÆ D(i)

Leaves of *Phacelophrynium* are the favored wrappers for the baking of food on fires, and is said to impart flavor to *biking* and tadpoles. Bundles of cooked food, including *natək* and meat may be stored temporarily, suspended on sticks over the family hearths.

məglungən ZINGIBERACEÆ A(iii); B(ii)

Alpinia leaves are a substitute for *ləkek.*

naf naf GRAMINEÆ B(iii); B(iv)

Sections of the larger form of *Dinochloa* bamboo are gathered from the upper forest for the carrying of water to the caves and for storage there. Shorter lengths are used as cooking vessels *(lutlutan)*, into which most forms of Tasaday food may be stuffed for baking. When the Tasaday obtains rice from PANAMIN visitors, it is, with the addition of water, cooked in this manner.

nangamaytas POLYPODIACEÆ

When deer or pig is butchered in the caves or at camp sites, this fern foliage is gathered in preparation, and laid out to form a floor, apparently to absorb the blood. The whole matting is later discarded.

tagisi PALMÆ A(ii); B(i); B(ii); E

The large, dissected leaves of the *Heterospathe* palm are utilized as food wrappers. When butchering is performed away from the caves, this leaf is the usual wrapping for transportation of the meat.

C. Cordage:

The uses of cordage are, of course, associated with the quest for subsistence, aspects of which have been dealt with in the preceding sections. Many of the natural cordage described under trapping and hunting are used incidentally, and plants used appear to depend on proximity to a given activity site rather than specific suitability. The rattans are one such group, and the split stems of *ləfunuq, salanay* and *sufini* are seen as the materials in many tying and binding uses. In this short list of other cordage then, are the twisted fibers, whose manufacturing process is said to have been introduced by Dafal.

malagilan/magilan URTICACEÆ A(iii); B(iii); D(ii); F

The bast fibers from the bark of *Leucosyke capitellata* var. *eucapitellata* are twisted to make string adapted to a wide range of uses, including the tying of food bundles, personal adornment, and in the construction of small traps. Brown[14) records this species as a producer of strong bast fibers through many of the Philippine islands.

uga/oga MUSACEÆ A(iii)

Many species of wild banana produce strong fibers from their pseudostems. The Tasaday use *Musa errans,* twisting the fibers into long lengths, again for many purposes. This is a common practice throughout Southeast Asia and much of Oceania.[15] *M. textilis* Nee is the common wild species for this purpose in the Philippines.[14]

D. **Body adornment and care:**

(i) Clothing, Decoration

bangi AMARYLLIDACEÆ

The leaves of *Curculigo capitulata* are the main apparel of the Tasaday, from which are fashioned the men's G-string consisting of a selected single wide leaf, and the women's skirt made of a number of them. Bundles of such leaves are common in the loads of the Tasaday returning to the caves from forays in the forest. The species is distributed mainly on the stream bank area. Such apparel may be worn for up to 3 days.

inay wagan LEGUMINOSÆ

The *bangi* clothing is tied with the vines of *Desmodium laxum,* and is the most comfortable of all the possible alternative materials available in the forest, in its flexibility and smoothness.

ləkek MARANTACEÆ B(vi)

The leaf of *Phacelophrynium* is an alternative to *bangi,* somewhat stiffer, and has narrower width.

sufini/sufing PALMÆ A(ii); A(iii); C

The rattan earrings occasionally worn by Tasaday women are mostly fashioned from *Calamus ornatus* stems. Whether this ornamentation is a recent influence brought in by Dafal is a debatable point. In favor is the general acknowledgment among the Tasaday that Dafal introduced ear-piercing to them.

timbagan ORCHIDACEÆ

Leaves of *Plocoglottis wenzelii,* a ground orchid, are the second substitute for *bangi.* The stiffness and hard midrib of this leaf, however, makes this species the least worn of the three possible choices.

(ii) Toilet

lagədan tolung URTICACEÆ

Leaves of *Cypholophus moluccanus* are used as toilet paper, and bundles are often brought to the caves used for infants.

mələfakid SAPOTACEÆ A(iii); F

The inner bark of the tree, *Palaquium* sp., is reputedly used after pulping with handy stones as soap for washing in the stream. A grayish clay deposited in some parts of stream beds is occasionally used also as soap.

malagilan URTICACEÆ A(iii); B(iii); C; F

The rough under-surface of the leaf of *Leucosyke capitellata* is used for polishing teeth.

E. Stimulants:

As in many indigenous societies of Southeast Asia, the betel-chewing habit is common among the Tasaday, men and women, but less noticeable in the children. The usual ingredients of the kernel of the *Areca* nut, the betel leaf from the *Piper* vine and lime (*afug*), here made from the heat-reduction of the collected shells of a land snail (probably a species of *Cyclophorus*), are supplemented by a considerable range of stems and barks of shrubs and trees of the forest.

buy/bui PIPERACEÆ

This is the main leaf used for chewing with *Areca* nut and lime, and is probably close to if not *Piper betle* L. (no fertile specimens were found, cf. other *Piper* spp.). This is the product of the Tasaday forest called *biyu* by Fernandez and Lynch ²⁾ which was reputedly one of the reasons for Dafal's repeated visits.

bulahəl PALMÆ A(ii); B(ii); E

This unnamed *Areca* palm is a secondary source for betel nut, a smaller and somewhat more bitter form than that yielded by *kohan*.

kohan PALMÆ A(ii)

The principal betel nut used by the Tasaday comes from *Areca caliso*, a common substitute for *Areca catechu* L. in the Philippines. ¹⁴⁾

lawingan adaw PIPERACEÆ

Short young stem sections of this unnamed *Piper* vine are often seen at the caves; they are chewed with lime, and *buy* leaf when available.

maganaw PALMÆ A(ii)

The small fruit of *Pinanga maculata* is a substitute for *kohan*.

mamagan manok GESNERIACEÆ

Mature leaves of *Cyrtandra tagaleurum* are chewed without *buy*, lime or *kohan*. The taste is somewhat sour.

səlufeng VERBENACEÆ

The somewhat aromatic twigs and bark of *Callicarpa cumingiana* are chewed together with *kohan* and lime.

səlufeng VERBENACEÆ F

The bark of this verbenaceous tree, *Geunsia*, is used similarly as *Callicarpa*. The coincidence of the two names was not noted during collection of the plants. That this name may be a general name for bark-chews is a possibility that another bark so used (sterile specimens of the tree were not collected) was called *səlufeng* also; the genus was noted as *Cinnamomum* of the family *Lauraceæ*.

tagisi PALMÆ A(ii); B(i); B(ii); B(vi)

The fruit of this *Heterospathe* palm provides a substitute for the *kohan* nut.

tufi VITACEÆ

for chewing with *afug*. No leaf was recorded as an accompaniment.

Sections of the vine of this undetermined climber are used

F. Firewood:

Table 4 presents what must be an incomplete listing of the forest genera used for firewood. The high canopy oak and dipterocarps are represented by *maliafa* and *mangəbə* respectively. In field observations however, live trees of such species are seldom cut; they are exploited rather as fallen and often partially rotted trees, while cutting of standing timber is generally limited to the smaller species and shrubs. Thus, while standing stumps of large trees remain rarities in the Tasaday forest, there appears to be increasing evidence of the use of the *bolo* and the axe, sometimes borrowed from PANAMIN personnel, among the trees below 20 cm in diameter in the vicinity of the caves, but beyond the requirements of path and site clearing for the visitors.

The Tasaday were unspecific about the wood used for the fashioning of their fire drills, and the two samples encountered were said to be made of *maliafa* (*Lithocarpus*). The tinder appeared to be of a considerable variety of dried plant material, but in the information given us on firewoods, *tuməlan wayug* (*Erechtites*) was one entry whose dried leaves and stems were observed in use for this purpose.

Some unlikely "firewoods" recorded were the climbing *budakan* (*Psychotria*) and *kabugatan dakal* (the sappy large *Freycinetia*). Apparently these, used only partially dry, are the smouldering elements which, after cooking, prolong the fire and may have the additional property of producing smoke as a deterrent to flies.

G. Building materials:

The cave dwellers have little use for building materials, and those that were noted in 1972 were contended by our informants to be largely the results of contact with Dafal. Temporary overnight shelters in the forest may be one example, for simply cleared patches prepared for over-nighting are more often encountered in the Tasaday domain. The examples of constructed shelters seen were crudely built single roofs sloping to the ground, with props and one or two suspension poles made of the most convenient and relatively straight saplings. Tying is effected with any of the abounding vines and epiphytic stems of the forest. Few specific requirements as regard these materials could be defined from our ethnobotanical enquiries, but the following information was volunteered:

anafa mahagtaw CYATHEACEÆ (Fern) B(iii)

The fronds of the large *Cyathea* form is one of the best materials for the roof of a temporary shelter, combined with *Dicranopteris*. The two kinds of leaves are piled on to the crude roof frame quite thickly, seemingly without real patterning and certainly without interlacing, or any manipulation which might suggest the crudest thatching.

basag PALMÆ A(i); A(ii); B(ii); F

Strips (some 6-10 cm wide) of bark from young *Caryota* palms are used for the construction of the sleeping platforms in the caves. Said to be an innovation to the living style, these platforms provide some immediate physical definition to the family units or hearths within the caves.

buluhəl PALMÆ A(ii); B(iii); E

Probably because of the large leaflets of this *Areca* (108890) palm, this is one of the favored roofing materials for shelters.

H. The nonsubsistence uses:

We recorded a range of nonsubsistence plants of varying cultural importance. This cannot be considered exhaustive, for in enquiries on plants of suspected medicinal or "religious" significance, we often drew evasive answers.

(i) Medicine

The reliance of the Tasaday on the PANAMIN doctor and his medicines was obvious from our enquiries, after we had enumerated all the plant uses for our collection, and found so few medicinal uses. The stimulants (E above) were not regarded as *bulung* (medicines), and we could not add to our meager list with direct and leading questioning.

aglunay ZINGIBERACEÆ

The juice of the lower stem of *Globba parviflora* (108824) was said by one informant to be an antidote for snake-bite. He quickly added, that there was one in the group who dealt with this problem. When the "specialist" was interviewed, he confirmed that he could cure snake-bites, but denied that *aglunay* was the plant used. He admitted that plants were involved in the formulation of the cure, but said that he could not divulge any fuller information that his father had taught him. He said that he did not know cures for other afflictions.

glabu dakal URTICACEÆ

The succulent stems of *Pellionia mindanaensis* often found growing epiphytically, exudes a sap of broad antidotal use against insect bites and contact with poisonous plants, especially *segaq* or *Dendrocnide stimulans.* The effectiveness of the cure seemed to be borne out by the experiences of some of our party thus affected; on application there was an immediate cessation of the burning sensation, the result of contact with the common seedlings of *Dendrocnide* in the Tasaday forest. A claim by one informant that the succulent stem is used to stop profuse bleeding in childbirth could not be corroborated.

(ii) Restricted Plants

The plants in the immediate area to the front of the Tasaday caves and leading down to the stream is an area in which the cutting and felling of plants and trees is prohibited. It is not, however, a "tabu" area, for some trails bissect it, children play in it and there is evidence for the plucking of leaves of such species as *nangamaytas* and *ləkek* (see B(vi) above) and *lagədan tolung* (D(ii) above). We avoided plant collection in this area, but in documenting the uses of two plant samples found 1 to 2 kilometers upstream from the caves on separate occasions, our Tasaday informants were quite concerned, would not handle the specimens, and once, abruptly left after telling us that it would rain because we had cut the plants.

bulaktiq ARACEÆ

Aglaonema marantifolium, also known as *A. commutatum* Schott, is an aroid herb, distributed in the Molucca and Celebes archipelagoes.[11] The genus of wider Southeast Asian distribution has common usage as a traditional medicine for various ailments. In Tasaday, there is a rather extensive and conspicuous clump of this species growing at the mouth of the upper cave, surmounting an ash midden that is still being added to.

This threat of rain also appears to be the penalty for damaging any of the plants at the cave-front and there appeared to be a cognized supernatural association with mention of the anger of *mabulah ulu,* identified as the "owner" of the cave. However, this term seems to have no exclusiveness, for it (literally "white head") was applied to at least two blonde visitors without any sign of religious connotation with respect to the recipient, or daring to use such a term in a secular way. When two boys fell in December, 1972, however, a new dimension of penalty for damaging this vegetation became apparent. They had been throwing stones inside and outside of the caves, and the illnesses were attributed to this malfeisance, with damage to the plants and the disturbance within the caves inseparable at least in my (D.Y.) enquiries.

matalum LEGUMINOSÆ

No fertile specimens could be found of this branched, small tree which grew outside the lower of the three caves occupied by the Tasaday, and we are at present unprepared to venture an identification of the genus. Prickly stemmed in both mature and the seedling forms, this plant may be found on the terrace sections upstream. At the cave, monkey and marsupial skulls can be observed hung on the branches of this tree, but this apparently recent practice has no particular significance; the skulls are even taken down by the children for play.

(iii) Toys

Tasaday children receive considerable and constant attention from adults, both men and women; toys are comparative rarity, and we do not know whether the string games common in Asia and recognized by some of the older Tasaday boys were a part of precontact culture. Dafal, of course, admitted introducing "cat's cradle," and to be sure, we never saw Tasaday children playing without prompting from us. Sticks, stones, fruits (especially of the edible Zingiberaceæ) were predictable objects of play, but only two more formal toys were seen:

nafnaf usa GRAMINEÆ B(iii); B(iv)

The smaller form of *Dinochloa* bamboo is used for the making of bows with which the young boys play. Bows and arrows, however, were seen made of different and unspecified springy woods which are common in the forest (see B(iv) above). Dafal's role in bringing both the hunting bow and the idea of the corresponding toy is undisputed by the Tasaday.

tambagan GRAMINEÆ

The lower sections of mature flowering stems of *Setaria palmifolia* are fashioned into whistles *(efewu)*, used by the boys to attract snakes in the shady undergrowth in localities where the reptiles are known to hide. When the snake appears, the boys say that they run away. There was no indication that this was a lure used, perhaps, in snake hunting.

DISCUSSION

Of the total of 210 botanical specimens collected (including 20 identified as duplicates taxonomically, but differentiated by informants), 120 were recorded as being plants useful in the Tasaday economy. The multiple use of individual species was a common characteristic. Although the total number of specimens is far from the total flora of the Tasaday forest, we consider that the main species of ethnobotanical value have been accounted for. Future collections will undoubtedly add to this knowledge, mostly in the categories (Table 1) of the technological aspects, e.g., equipment for food acquisition, cordage, and firewood, categories in which many alternative raw materials may be used.

Despite questioning as persistently as we were able to, we were unable to satisfy our curiosity on Tasaday medicinal plants that was prompted by the term *bulung* that was applied to medicine administered on the visits of the PANAMIN doctor. The list of two remedies including the contradicted "cure" for snakebite could not be supplemented. Furthermore, the extensive number of species chewed as stimulants could not be associated with medicine in our enquiries. It should be noted that our application of the term "stimulant" is itself our borrowing from Oceania and Southeast Asian characterizations of the habit of betel-chewing rather than a translation of a Tasaday term. Again, we could not find association between the plants we have called "Restricted Plants" which might have some supernatural connotations, and medicine, even those plants, or rather their damaging, was said to be associated with penalties of ill health. This line of enquiry is by no means satisfied at this juncture.

We think that we have covered the principal plant food sources, and most of the subsidiary, for neither by information and observation in two visits at different times of the year (July to August and December) nor with the supplementary observations of others, [2] (M. Elizalde and J. Nance, personal communications) no additions could be made to the enumeration. In this account we have reported root-producing species supplemental to *biking* in the diet — a further two species of *Dioscorea* yams and one *Smilax*. These three plants were shown to us, dug for our inspection and we shared in their tasting, but we did not record them as a regular component of normal foraging. However, we have established a somewhat broader base in terms of starchy food sources available to the Tasaday than *biking* and *natək* only, even though at present the new recordings have a status of alternative or supplement rather than foods of choice.

In regard to the "prehistory" of the Tasaday — the period before the advent of Dafal — when mammals and *natək* were apparently absent from the diet, we have been unable to enlarge significantly on the range of plant staples. The possibility of feasible alternative bulk foods to wild roots like heavy-bearing-nuts of tree species that might have endowed the earlier Tasaday diet with a quantitative and seasonal pattern of variation was not realized in our study. The roots of *biking* and perhaps the other tuberous species, even now rather sparsely distributed in the vicinity of the cave dwellings, must have been the main staple plant emphasis. This limitation, together with the former absence of the mammalian food sources, forces the consideration of a more extensive pattern of foraging in the time of pre-Dafal technology. The further analysis of this situation is the subject of a future paper in this series on the Tasaday.

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TABLE 1. — *The ethnobotanical classification of useful plants of Tasaday.*

	Uses		Number of species
A	Food plants		
	(i)	Starchy	5
	(ii)	Leaves and leaf buds	11
	(iii)	Flowers and fruit	31
	(iv)	Fungus	2
	(v)	Tree exudates	3
B	Food acquisition		
	(i)	Plant gathering	3
	(ii)	Faunal gathering	4
	(iii)	Natək production ("sago")	9
	(iv)	Trapping and hunting	15
	(v)	Bait	7
	(vi)	Wrapping and preparation	6
C	Cordage		2
D	Body care and adornment		
	(i)	Clothing, decoration	5
	(ii)	Toilet	3
E	Stimulants		10
F	Firewood		38
G	Building materials		3
H	Nonsubsistence uses		
	(i)	Medicine	2
	(ii)	Restricted plants	2
	(iii)	Toys	2

TABLE 2. — *Flowers and fruits in the Tasaday diet.*

Tasaday name	Family	Genus (PNH No.)**	Other uses
Amutmagiso	Liliaceæ	**Tricyrtis**	B(ii)
atas lulud*	Marantaceæ	Plagiostachys 108993	
balagilan/ malagilan*	Urticaceæ	Leucosyke 108860	B(iii);C;D(ii);F
baling awag	Melastomataceæ	**Melatostoma** 108883	
bangi *	Amaryllidaceæ	**Curculigo**	D(i)
balingawagan	Actinidiaceæ	Saurauia 108843	
balingawag dakal	Actinidiaceæ	Saurauia 108884	F

* denotes plants harvested for fruit alone; + for flowers only. Unmarked signifies that both flowers and fruits are eaten.

**Herbarium numbers are quoted where more than one species of unidentified sample of the genus were collected.

busikung ataw	Moraceæ	Ficus 108901	
bəlasinong *	Burseraceæ	Aglaia	F
budakan *	Actinidiaceæ	Saurauia 108893	
dalikan *	Zingiberaceæ	Amomum 108815	
finuqon *	Zingiberaceæ	Amomum 108888	
fusəw +	Araceæ	Schismatoglottis	A(ii)
kanag nagən *	Euphorbiaceæ	Aporosa	F
kofoe +	Balsaminaceæ	Impatiens	
kolo	Zingiberaceæ	Phaeomeria	
ləfunuq *	Palmæ	Calamus 108891	A(ii);C
linguon *	Actinidiaceæ	Saurauia 108813	
lugimit *	Moraceæ	Ficus 108828	F
mata usa *	Burseraceæ	Chisocheton	A(v);B(iv);F
məglugən*	Zingiberaceæ	Alpinia	B(ii);B(vi)
mələfakid*	Sapotaceæ	Palaquium	D(ii)
mogisalawa *	Melastomataceæ	Melastoma 108897	
oga *	Musaceæ	Musa	C
salanay *	Palmæ	Calamus 108952	A(ii);B(i);C; B(ii)
sufing/ sufini *	Palmæ	Calamus 108896	A(ii);A(iii); C;D(i)
syal dakal	Dilleniaceæ	Dillenia	F
tafodoy*	Actinidiaceæ	Saurauia 108830	
tafodoy*	Actinidiaceæ	Saurauia 108833	
tanto *	Rosaceæ	Rubus	
tselin *	Zingiberaceæ	Amomum 108827	
tule *	Zingiberaceæ	Amomum 108814	

TABLE 3. — *Fruits used for baiting traps for smaller animals by the Tasaday.*

Tasaday name*	Family	Genus (Herbarium No.)	Other uses
baliyango (B)	Pittosporaceæ	Pittosporum	F
bəlahauan (R)	Rubiaceæ	Praravinia	

Tasaday name*	Family	Genus (PNH No.)	Other uses
fəliyu ubal (M)	Euphorbiaceæ	Glochidion	F
kəlakaq (R)	Pandanaceæ	Pandanus 108953	
lubunan (M)	Pandanaceæ	Pandanus 108911	
mənilsil (B)	Rubiaceæ	Ixora	F
samgiqsiq (B)	Chloranthaceæ	Sarcandra	

* Animals baited are signified in parenthesis: B, birds; R, rodents and marsupials; M, monkeys.

TABLE 4. — *Firewood of the Tasaday forest.*

Tasaday name	Family	Genus (PNH No.)**	Other uses
balingawag dakal	Actinidiaceæ	**Saurauia 108884**	A(iii)
baliyangun	Sapindaceæ	**Allophylus 108862**	
baliyango	Pittosporaceæ	**Pittosporum**	B(v)
basikung usa	Moraceæ	**Ficus 108892**	
bəlasinong	Burseraceæ	**Aglaia**	A(iii)
bəli taqog	Rubiaceæ	**Ixoria 109014**	B(iv)
budakan	Rubiaceæ	**Psychotria 108967**	A(iii); B(iv)
fəliyu ubal	Euphorbiaceæ	**Glochidion**	B(v)
kabugatan dakal	Pandanaceæ	**Freycinetia 108987**	
kalikin	Sapindaceæ	**Allophylus 108879**	
kanagnagon	Euphorbiaceæ	**Aporosa**	A(iii)
kəitugitug	Rubiaceæ	**Lasianthus**	
kəletifoy	Melastomataceæ	**Medinilla 108920**	
kəlimataqan	Vitaceæ	**Cissus**	
kəluan iman	Euphorbiaceæ	**Breynia**	
lasuq ubal	Melastomataceæ	**Medinilla 108897**	
lugimit	Moraceæ	**Ficus 108828**	A(iii)
magaməm	Myrsinaceæ	**Maesa 108877**	
maktaqan	Moraceæ	**Ficus 108818**	
malaga bunga	Rubiaceæ	**Ixora 108996**	
malagilan/balagilan	Urticaceæ	**Leucosyke 108821**	A(iii); B(iii); C
maliafa	Fagaceæ	**Lithocarpus**	
mangəbo	Dipterocarpaceæ	**Vatica**	

mata usa	Burseraceæ	Chisocheton	A(iii); B(iv)
məkulad	Vitaceæ		
məlagulang	Araliaceæ	Boerlageodendron	
məlanabaq	Moraceæ	Ficus 108977	
mənilsil	Rubiaceæ	Ixora 109011	B(v)
moqok	Clethraceæ	Clethra	
samgalan	Annonaceæ	Goniothalamus	
səlufeng	Verbenaceæ	Geunsia	E
səmnuhuh	Casuarinaceæ	Casuarina	B(iv)
syaldakal	Dilleniaceæ	Dillenia	A(iii)
tangawan	Rubiaceæ	Mussaenda	
timbagək lambangan	Moraceæ	Ficus 108982	A(iii)
timlas	Euphorbiaceæ	Antidesma	B(i)
tuməlan wayəg	Compositæ	Erechtites 108955	
tungaw	Melastomataceæ	Astronia	B(iv)

APPENDIX 1

Plants of the Tasaday forest: The Preliminary Determinations*

Family	Identification	PNH No.
(Fungi)		
Aureculiariaceæ	**Auricularia auricula-judae** L.	108909
Polyporaceæ	**Daedalea** sp.	108908
	Fomes sp.	109017
	Ganoderma sp.	108906
	Polyporus sp.	108907
	Polyporus sp.	108938
	Polystictus sp.	108905
	Polystictus sp.	108990
	undetermined	108939

*The arrangement of this table with fungi, fern allies and ferns, followed by the angiosperm monocotyledons and dicotyledons. Families and genera are presented in alphabetical order for ease of reference from the text of the paper. The occurrence of more than one National Museum Herbarium No. for ony species indicates that there were replicate collections made; the repetition of species under identification represents those judged by the same species botanically, but separated by our informants as different entities.

(Fern Allies)		
Equisetaceæ	**Equisetum debile Roxb.**	108898
Selaginellaceæ	**Selaginella agusanensis Hieron.**	108871
(Ferns)		
Cyatheaceæ	Cyathea sp.	108903
	Cyathea sp.	108988
Gleicheniaceæ	**Dicranopteris linearis (Burm.) Und.**	108960
Polypodiaceæ	**Asplenium nidus D.**	108986
	Belvisia sp.	108989
	Cyclosorus sp.	108902
	Didymochlaena truncatula (Sw.) J. Sm.	108981
	Dryopteris sp.	108933
	Microsorium sp.	108869
	Undetermined	108965
(Angiosperms: monocotyledons)		
Amaryllidaceæ	**Curculigo capitulata (Lour.) O. Ktze**	108840
Araceæ	**Aglaonema marantifolium Bl.**	108895
	Alocasia sp.	108971
	Homalomena philippinensis Endl.	108829
	Schismatoglottis calyptrata (Roxb.) Z. & M.	108899
Commelinaceæ	Aneilema vitiense Seem. var. var. petiolatum Clarke	108857
	Commelina capitata (Bl) clarke	108854
Cyperaceæ	**Carex continua C.B. Clarke**	108954
	Carex philippinensis Nelmes	108935
	Mapania cuspidata (Miq.) Uitt.	108956
	Scleria scrobiculata Nees.	108926
Dioscoraceæ	**Dioscorea divaricata Blanco**	108999
	Dioscorea sp.	108941
	Dioscorea nummularia Lam. (?)	109010

Graminaeæ	Dinochloa luconiae (Munro) Merr.	108975
	Dinochloa luconiae (Munro) Merr.	108979
	Echinochloa crus-galli L.	108961
	Garnotia stricta Brogn.	108835
	Miscanthus floridulus Labill.) Warb.	108923
	Setaria palmifolia (Koen.) Stapf.	108823
Liliaceæ	Smilax china L.	109019
	Smilax elmeri Merr.	108900
	Tricyrtis sp.	108822
Marantaceæ	Phacelophrynium bracteosum (Warb.) K. Schum.	108832
	Plagiostachys philippinensis (Ridl.)	108993
	Plagiostachys sp.	108951
Musaceæ	Musa errans (Blco.) Teodoro	108817
Orchidaceæ	Appendicula microcantha Lindl.	108872
	Bulbophyllum emiliorum Ames & Quis.	108870
	Dendrochilum cagayanense Ames	108873
	Dendrochilum longispicatum Ames	108875
	Dendrobium sp.	108968
	Eria ovata Lindl.	108871
	Phalaenopsis sp.	108961
	Plocoglottis wenzelii Ames	108841
Palmæ	Areca caliso Becc.	108995
	Areca sp.	108890
	Calamus mindorensis Becc.	108952
	Calamus ornatus Bl. & Schultz var. philippinensis Becc.	108896

	Calamus sp.	108891
	Caryota cumingii Lodd.	108978
	Heterospathe sp.	108976
	Pinanga maculata Porto	108861
Pandanaceæ	**Freycinetia** sp.	108897/108987
	Freycinetia sp.	108943
	Freycinetia sp.	108949
	Pandanus	108863
	Pandanus	108911
	Pandanus	108953
Zingiberaceæ	**Alpinia** sp.	108947
	Amomum sp.	108814
	Amomum sp.	108815
	Amomum sp.	108827
	Amomum sp.	108888
	Globba parviflora Presl	108824/108831
	Globba parviflora Presl	109015
	Phaeomeria excelsa (Jack) Merr.	108876
(Angiosperms: dicotyledons)		
Acanthaceæ	**Staurogyne ciliata** Elm.	108850
Actinidiaceæ	**Saurauia clementis** Merr.	108830/108833
	Saurauia elegans (Choisy) F.-Vill.	108921
	Saurauia involcrata Merr.	108843
	Saurauia latibractea Choisy	108884
	Saurauia sp.	108813
	Saurauia sp.	108893
Annonaceæ	**Goniothalamus** sp.	108985
Araliaceæ	**Acanthophora scandens** Merr.	108928
	Aralia bipinnata Bl.	108974
	Boerlageodendron sp.	108946/109003
	Schefflera sp.	108948

	Schefflera sp.	109018
Balsaminaceæ	**Impatiens** sp.	108812
Begoniaceæ	**Begonia aequata** A. Gray	108887
	Begonia cumingii A. Gray	108970
	Begonia pseudolateralis Warb.	108838
	Begonia sordidissima Elm.	108819/108889
Boraginaceæ	**Tournefortia** sp.	108881
	Undetermined	108847
Burseraceæ	**Aglaia** sp.	108864
	Chisocheton sp.	109004
Campanulaceæ	**Pratia nummularia** (Lam) Kurz.	108940
Casuarinaceæ	**Casuarina rumphiana** Miq.	108922
Chloranthaceæ	**Chloranthus officinalis** Bl.	108962
	Chloranthus officinalis Bl.	109016
	Sarcandra glabra (Thunb.) Nakai	108957/109006
Clethraceæ	**Clethra luzonica** Merr.	109001
Compositæ	**Ageratum conyzoides** L.	108825/108904
	Erechtites hieracifolia Rafin.	108955
	Erechtites valerianaefolia (Wolf.) DC.	108950
	Lactuca laevigata (Bl.) CC.	108878
	Spilanthes acmella (L.) Murr.	108826
Cucurbitaceæ	**Melothria mucronata** (Bl.) Cogn.	108918
	Trichosanthes sp.	108910
Dilleniaceæ	**Dillenina megalantha** Merr.	108886
Dipterocarpaceæ	**Vatica** sp.	109005
Euphorbiaceæ	**Antidesma cumingii** Muell.-Arg.	108966
	Aporosa sp.	108984
	Breynia cernua (Poir.) Muell.-Arg.	108927
	Glochidion lancifolium C.B. Rob.	108942

Fagaceæ	Lithocarpus sp.	108865
Gesneriaceæ	Cyrtandra tagaleurum Kranzl.	108959
	Isanthera discolor Maxim.	108837
	Rhynchoglossum obliquum Bl.	108882
Gunneraceæ	Gunnera macrophylla Bl.	108934
Labiatæ	Scutellaria indica L.	108844
Leguminosæ	Abarema elliptica (Bl.) Kosterm.	108846/108852
	Desmodium laxum D.C.	108894/109007
	Desmodium laxum D.C.	108820
	Strongylodon sp.	108929
	Abrus sp. (?)	108932
Magnoliaceæ	Kadsura philippinensis Elm.	108963
Melastomataceæ	Astronia subcaudata Merr.	109002
	Dissochaeta celebica Bl.	108992
	Medinilla astronoides Triana	108859
	Medinilla involucrata Merr.	108855
	Medinilla teysmanii Miq.	108880
	Medinilla sp.	108885
	Medinilla sp.	109013
	Medinilla sp.	108997/108920
	Melastoma mindanaense Merr.	108883/108897
Menispermaceæ	Stephania corymbosa (Bl.) Walp.	108994
Moraceæ	Ficus ampelos Burm. f.	108857
	Ficus botryocarpa Miq.	108901
	Ficus cassydiana Elm.	108892
	Ficus congesta Roxb.	108982
	Ficus conora King	108845
	Ficus minahassae (Teysm. & De Vr.) Miq.	108828
	Ficus septica Burm. f.	108818/108842
	Ficus septica Burm. f.	108839/108924

	Ficus subulata Bl.	108973
	Ficus virgata Reim. ex Bl.	108977
Myrsinaceæ	Maesa denticulata Mez.	108877
	Maesa sp.	109009
Piperaceæ	Piper caninum Bl.	108866
	Piper cordatilimbum Quis.	108930/108999
	Piper langlassei C.D.C.	108914
	Piper umbellatum L. var. suppeltatum (Willd.) C.D.C.	108916
	Piper sp.	108868/108998
Pittosporaceæ	Pittosporum moluccanum (Lam.) Miq.	109000
Ranunculaceæ	Clematis Javana D.C.	108915
Rosaceæ	Rubus farxinifolius Poir.	108816
Rubiaceæ	Borreria laevis (Lam.) Griseb.	109012
	Hydnophytum formicarum Jack.	108991
	Ixora bartlingii Elm.	108945/109011
		108996/109014
	Lasianthus sp.	108931
	Mussaenda philippica A. Rich.	108958
	Praravinia mindanaensis (Elm.) Brem.	108944
	Psychotria luconiensis (Cham. & Schlecht.) F.-Vill.	108967
	Psychotria sp.	108983
	Rubia cordifolia L.	108980
Sapindaceæ	Allophylus macrostachys Radlk.	108862
	Allophylus macrostachys Radlk.	108879
Sapotaceæ	Palaquium sp.	108937
Saxifragaceæ	Hydrangea sp.	108853
Urticaceæ	Cypholophus moluccanus (Bl.) Miq.	108917
	Cypholophus sp.	108913

	Dendrocnide stimulans (L.f.) Miq. ex Zoll.	108936
	Elatostema lutescens C.D. Rob.	108834/108836
	Elatostema sp.	108848
	Elatostema sp.	108858
	Leucosyke capitellata (Poir.) Wedd. var. eucapitellata M. Unruh	108821/108860
	Leucosyke nivea C.B. Rob.	108851
	Pellionia mindanaensis C.B. Rob.	108849
Verbenaceæ	Callicarpa cumingiana Merr.	108972
	Clerodendron intermedium Cham.	108811/108919
	Geunsia sp.	109008
Vitaceæ	Cissus assamica Craib.	108925
	Leea aculeata Bl.	108912
	Undetermined	108969

ILLUSTRATIONS

PLATE 1

The forest of the Tasaday: The lighter V-shaped patch at upper left is a tract of secondary growth, the result of natural erosion.

PLATE 2

FIG. 1. Balayəm, (a Tasaday), using a digging-stick made from the bark of *Areca caliso*, excavates for a tuber of the wild yam, biking (*Dioscorea* sp.); having prepared the hole for a large yam, he was disappointed in the short, thin tuber that he obtained on this occasion.

FIG. 2. The results of gathering: Balayəm carries a partially trimmed *ubod* shoot from a young *Caryota palm*, while his wife Sindi bears the fruits of a *Calamus* species.

SHORT COMMUNICATION

STUDIES ON THE FUEL CELL

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INTRODUCTION

This paper describes some exploratory studies being conducted in our laboratory in the field of fuel cells. This field is relatively new in this country. Because of the energy crisis, enthusiastic research activities have been started in the areas of solar energy, wind power and other nonconventional energy sources. The immediate potential is perhaps not as pronounced but fuel cells definitely belong to the list of feasible energy sources of the future.

Despite recent reports of one or two commercially successful systems,** the present world-wide status of fuel cell technology may be generally described as being still in the research and development stage. Most of the fuel-cell batteries that have been built were for demonstration purposes or for highly specialized applications such as those used in NASA's Gemini and Apollo flights.*** Considerable work in this field is currently in progress in the advanced countries, notably, the United States, England, West Germany, and Russia. We have no information on any local research efforts on fuel cells. In our laboratory, work was begun last year on silver-catalyzed electrodes. These have been developed with some degree of success and are now being used in experimental zinc-air and hydrazine-air systems.

Fuel cell background. Fuel cells are electrochemical devices in which electricity is produced directly by the reaction of a gas or liquid fuel supplied to one electrode and oxygen or air supplied to the other. This directness in conversion results in higher efficiency since the Carnot cycle limitation does not apply. Some distinct advantages of the fuel cell over conventional batteries are: *(1)* possibility of continuous unattended operation, *(2)* higher power per unit weight or volume, and *(3)* clean and quiet operation.

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* To whom correspondence is to be directed.

** Sanyo Electric Co., TechnoCrat, 5 (5) (1972), 13.

*** H. Harvey, *Chem. & Ind.*, (9) (1965), 367.

Philipp. J. Sci., 103 (2), 1974: 141-146.

Fuel cells are of many types and are usually classified according to the operating temperature or the type of fuel used.[†] For low temperature cells (50° to 150°F), which are our interest, powerful catalysts are needed to get good reactivity. The best catalysts so far are based on the noble elements like platinum, iridium and palladium. Silver is a less expensive alternative and is the basis of our catalytic electrodes.

The air-breathing electrode: Method of fabrication. — In the air-breathing catalytic electrode, oxygen from the air enters the exposed face and diffuse through the porous electrode until it meets the electrolyte at a three-phase boundary of electrode, oxidant and electrolyte. Here, silver catalyzes the energy-giving electrochemical reaction.

Excellent discussions of fuel cell theory are available in standard texts on the subject such as that by Sutton.[††] The literature, however, is not as explicit when it comes to actual methods of preparing catalytic electrodes.

The problem of making a suitable electrode structure is essentially that of dispersing the metal catalyst to provide a high reaction area and controlling the porosity of the structure such that the activation interface is at an interior region. The electrode, in addition, must be a good electrical conductor, have reasonable mechanical strength and be resistant to the corrosive electrolyte. We found after extensive trial that most of these requirements are met by the following method of preparing the catalyst and pressing the electrode:

> Silver carbonate (about 30 g per electrode) is mixed with equal amounts of acetic acid and water, and the foaming mixture stirred continuously. About 80-per cent hydrazine hydrate is then added as a reducing agent. The silver particles, which settle to the bottom of the container, are washed with ammonium hydroxide to remove the unreduced Ag_2CO_3. Unreacted hydrazine is then removed by washing with water until the pH is neutral. The product is now catalytically active silver with high surface area.
>
> The next step is to incorporate the catalyst in an inert porous binder. Aqueous Teflon is used for this purpose. The viscous dispersion is even dried at 200°C to 240°C for 1 hour and then cured for 30 minutes in a 500°C oven. The porous, brittle product is then reduced to powder by use of a 28-mesh Tyler screen.
>
> To fabricate the electrode, Teflon powder is spread over a 100 sq cm mold and on top of this is placed a uniform layer of the prepared catalyst.

[†] N. P. Chopey, Chem. Eng., 71 (11) (1964), 125.

[††] G. W. Sutton, Direct Energy Conversion, McGraw Hill Book Co., 1966.

The layered powders are pressed at 10,000 lbs for 15 seconds after which the pressed layer is placed between heated metal plates at 750°F. The electrode is cooled and subjected to a final pressing at 20,000 lbs. The 100 sq cm electrode, consisting of silver catalyst with Teflon backing, is now ready for use in the fuel cell.

The fuel cell. — The zinc-air fuel cell has the above electrode as cathode, zinc as the anode and KOH as electrolyte. The overall cell reaction is

$$Zn + \frac{1}{2}\, O_2 + 2\, KOH \rightarrow K_2ZnO_2 + H_2O$$

The prototype bicell constructed in our laboratory had two 100 sq cm cathodes mounted in plastic frames, with a thin nylon cloth stretched over each catalytic surface. To each cathode is pressed a strip of nickel which serves as contact terminal. The two cathodes face a common zinc anode; the bicell thus has two single cells connected in parallel.

The bicell has a rectangular opening at the top for electrolyte filling and for conveniently inserting the zinc anode. In this manner, the cell may be mechanically recharged by simply replacing the electrolyte solution and the anode.

Performance curves were obtained for the above system. A typical result is shown in Figure 1.

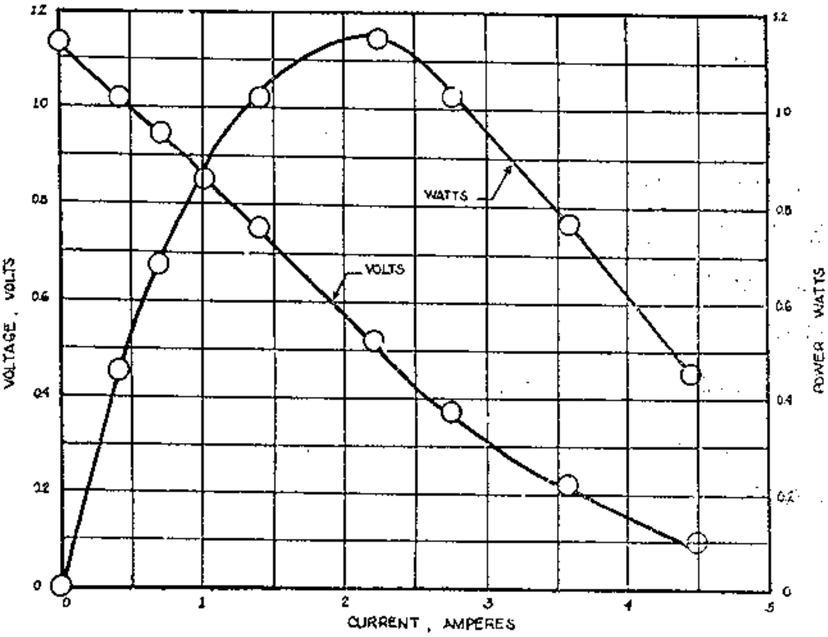

Fig. 1. Performance and power curves for experimental zinc-air fuel cell.

The hydrazine-air fuel cell uses the air-breathing electrode as cathode and porous nickel as anode. The bicell structure is somewhat more complicated than in the zinc-air system; the fuel compartment is separated from the electrolyte compartment by the anode. The schematic diagram in Figure 2 illustrates the arrangement.

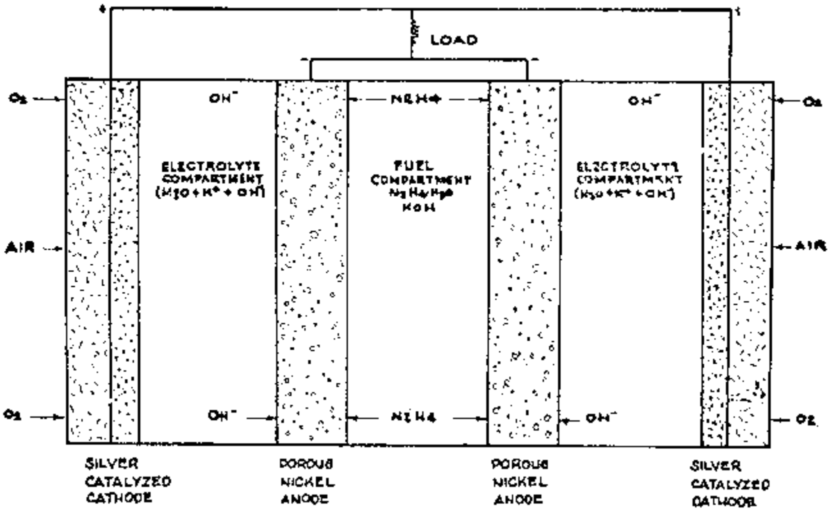

Fig. 2. Schematic diagram of hydrazine-air bicell.

Acrylic frames and nickel contacts were again used in this bicell. Hydrazine hydrate at 30-per cent concentration was used as fuel. The overall cell reaction may be written as follows:

$$N_2H_4 + O_2 \rightarrow N_2 + 2H_2O$$

The actual electrochemical process occurs through two steps[†]:

$$N_2H_4 + 4OH \rightarrow N_2 + 4H_2O + 4\bar{e} \quad \text{(anode)}$$

$$O_2 + 2H_2O + \rightarrow 4OH- \qquad \text{(cathode)}$$

[†] G. Evans and K. V. Kordesch. Sci., 158 (1967), 1148.

Figure 3 shows the result of our performance tests on the hydrazine-air bicell.

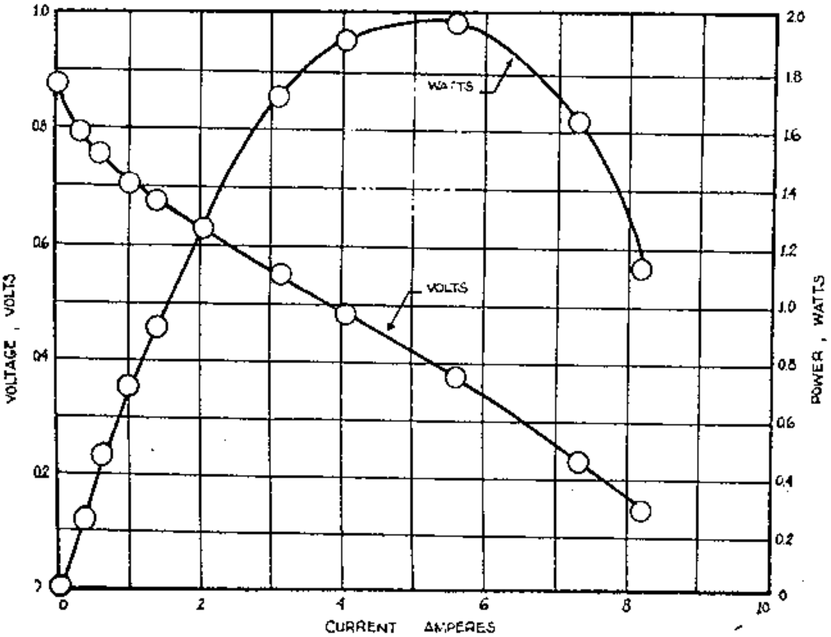

Fig. 3. Performance and power curves for experimental hydrazine-air fuel cell.

Duration tests. — A series of 10 zinc-air bicells was arranged as a module and made to run a 12-volt, 17-watt TV set (Plate 1). At the start, a single load of zinc anodes lasted about 3 hours. This operating time decreased rapidly until the lapse of 2 weeks when the unit had to be recharged every 15 minutes.

Dissection of a used bicell revealed the reason for this drop in efficiency. Powdery deposits had accumulated on the nylon separators thus effectively decreasing the useful electrode area. These deposits were probably impurities from the zinc plate as well as from the reaction product K_2ZnO_2.

For the hydrazine-air system, 18 bicells were connected in series and also made to run a 12-volt, 17-watt TV set (Plate 2). The test was intermittent: the cells were charged with a N_2H_4 — KOH mixture at 8 a.m. and the TV set turned off at 5 p.m. Two months of testing in this manner affected the power of the module only slightly. After this period, some of the cells began to show decreased output. At the time of writing (about 5 months after the start of duration testing), six cells have already been changed. A major problem observed was corrosion of the metal contacts and leakage in the cells.

CONCLUSION

Much remains to be done before the fuel cell can become a practical energy source. We are at present devising a method of continuous feeding of hydrazine fuel in the hydrazine-air system. The object is to develop a prototype of a self-contained system — a "power package" capable of unattended operation. Despite the mechanical recharging disadvantage of the zinc-air battery, this may be a less expensive system. Methods are also being devised to improve its operating efficiency.

Preliminary costing estimates indicate the high cost per watt of power available in the above system. This is generally true of fuel cells as compared to other energy sources. This should not deter local workers, however, from pursuing research in this area. With the hugely funded efforts going on in other countries, breakthroughs in the technology — such as cheaper catalyst combinations — are inevitable. We should be in a position to benefit from such advances.

ACKNOWLEDGMENT

The authors are indebted to the financial support and the encouragement provided by the NSDB and the Office of the President's Project Sta. Barbara at whose laboratories this research is being conducted. Gratitude is also due Dr. Max Goldberger for providing the initial impetus to this work.

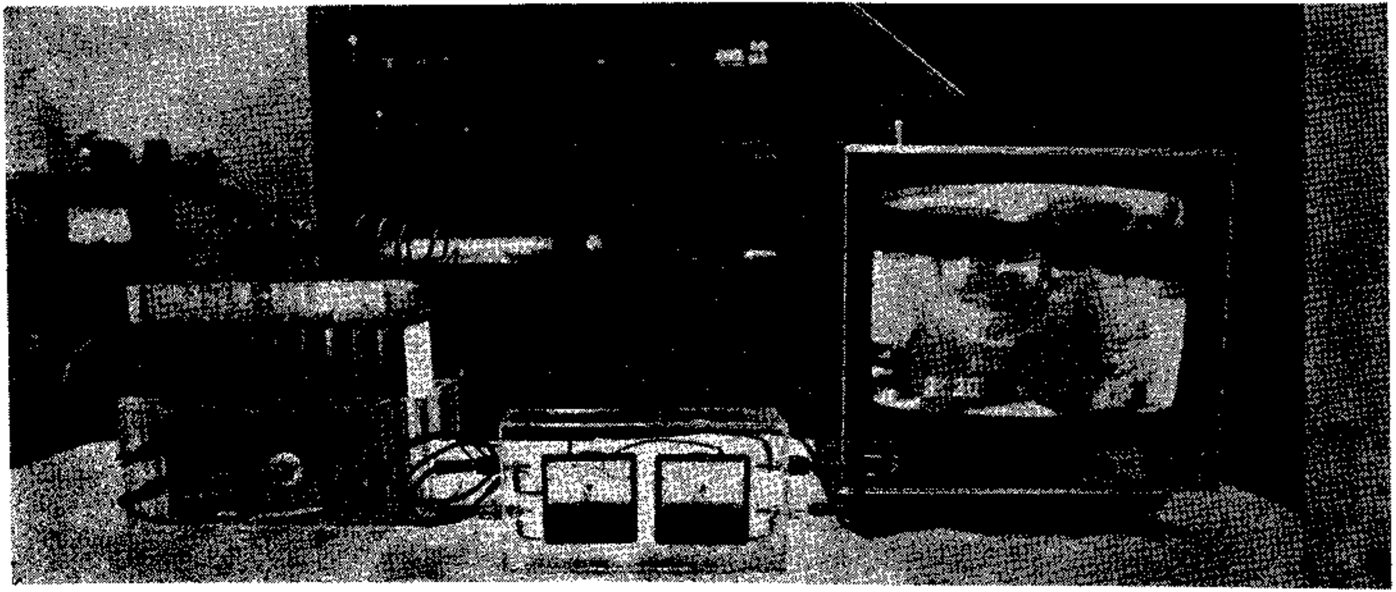

PLATE 1. THE EXPERIMENTAL ZINC-AIR BATTERY.

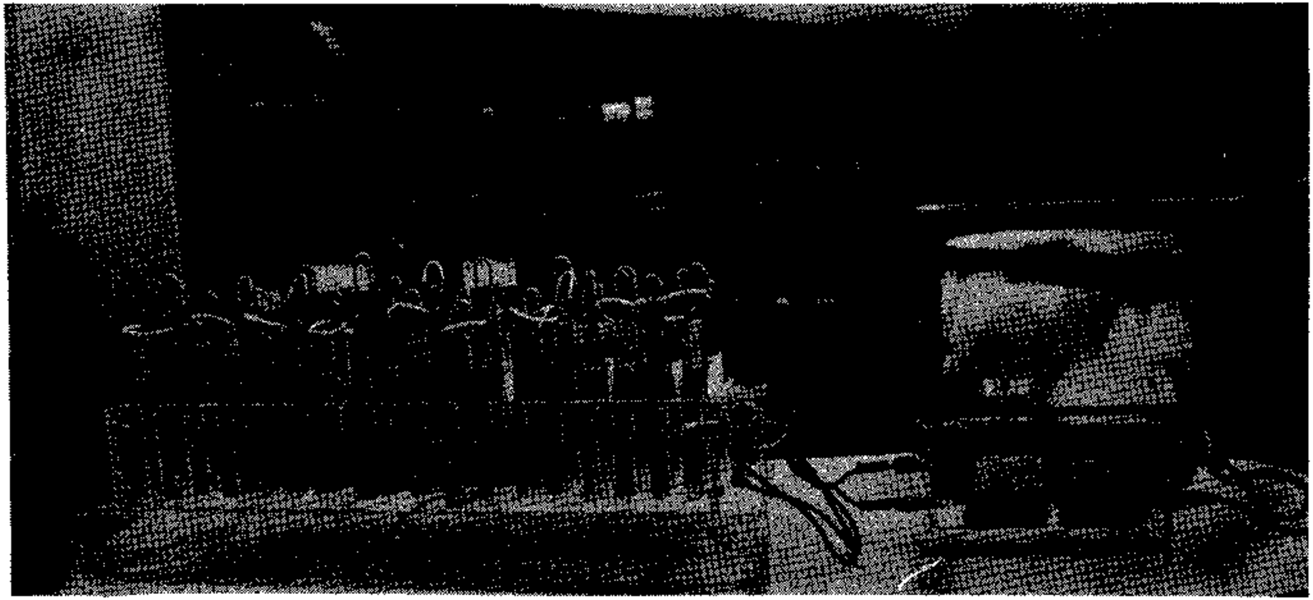

PLATE 2. THE EXPERIMENTAL HYDRAZINE-AIR BATTERY.

EDITORS' NOTE

The editorial staff of the *Philippine Journal of Science* has made some changes in the publication style of the journal. The staff made these changes so as to observe guidelines set by UNISIST aimed at systematizing the style of scientific and technical reports.

Rules for printing of signs, symbols, and units have been adopted from ISO Recommendations and ISO Standards. Abbreviations of names of journals follow the International List of Periodical Title Word Abbreviations, a UNISIST guidebook.

Citation of a publication will henceforth be indicated in the text by an Arabic numeral typed as superscript followed by a close parenthesis. The collection of references that appears at the end of a manuscript will observe the forms listed below:

1. Citation of a Journal (arranged in order): abbreviated first name of author preceding family name, abbreviated name of journal, volume number, year of publication enclosed in parentheses, starting page of article cited.

2. Citation of a patent: abbreviated first name of inventor preceding family name, kind and number of patent, year of patent application enclosed in parentheses, abbreviated name of abstract journal where the abstract of the patent can be found, year of publication, page number.

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We hope that these changes will serve the purpose of keeping us on constant alert for the latest news in the scientific community and make our communications system more effective.

FOURTH INTERNATIONAL GONDWANA SYMPOSIUM

Organizing Committee
Geological Survey of India
27 Jawaharlal N. Road
Calcutta-13

ANNOUNCEMENT

The IV International Gondwana Symposium (under the auspices of the International Union of Geological Sciences) sponsored by the Geological Survey of India will be held at Calcutta in February 1977. The following sectional topics have been chosen for presentation of papers and discussions:

Section I: Palaeogeography
Section II: Gondwana Flora
Section III: Gondwana Fauna
Section IV: Environment and Origin of Coal Deposits
Section V: Glacial Deposits
Section VI: Stratigraphy of the Marine and Non-Marine Gondwana Deposits
Section VII: Sedimentology
Section VIII: Tectonics, Igenous Activity, Geochronology & Structural Geology

An integral part of the programme will be five or six post-session field trips to areas of special significance to Gondwana Geology.

Contributions from researchers in these fields are welcome. The abstracts of papers (in two copies) not exceeding 200 words, should reach the Chairman, Organizing Committee by 30th June 1975 and two copies of the complete type-written text of each paper together with the plates and illustrations, if any, should reach the Chairman, before 1st July 1976.

WASHINGTON DC
USA

XV
INTERNATIONAL CONGRESS OF
ENTOMOLOGY

AUGUST 19-27
1976

XV International Congress of Entomology

First Announcement

The 15th International Congress of Entomology will be held in the beautiful capital city, Washington, D.C., U.S.A., August 19–27, 1976, under the sponsorship of the National Academy of Sciences and the Entomological Society of America. Sessions will be held in the excellent meeting facilities of the Washington Hilton Hotel. Special events are being planned at national scientific and cultural centers. Two international airports near Washington give direct access from abroad. University housing will be available in addition to hotel facilities.

The Organizing Committee for the Congress is composed of Curtis W. Sabrosky (Chairman and President of the Congress), Ernest C. Bay (Secretary-General), Wallace P. Murdoch (Treasurer), William G. Eden, Gordon E Guyer, E. F Knipling, Robert L. Metcalf, John V. Osmun, Ray F. Smith and Edward O. Wilson

The program will emphasize plenary symposia, invitational speakers, specialized symposia/work groups/panel discussions, and special interest groups or informal conferences. Thirteen program sections cover Systematics, Genetics, Physiology and Biochemistry, Toxicology, Ecology, Behavior, Social Insects and Apiculture, Biological Control, Medical and Veterinary Entomology, Agricultural Entomology and Pest Management, Forest Entomology, Stored Products and Structural Insects, and Pesticide Development, Management and Regulation.

A Congress Brochure and application forms will be mailed in May, 1975. The Brochure will contain information on highlights of the scientific program, receptions, tours, ladies program, scientific, historical and other features of the Washington area, and useful data for visitors.

PLEASE NOTE: Announcements of this Congress are not being sent to individuals, but are being publicized in journals and circulated to museums, departments, and other institutions. If you are interested in receiving future information, including registration forms, please send a postcard to the undersigned with your name and address, **typed or in block letters**, and also the section of your major interest.

Dr. ERNEST C. BAY, **Secretary General**
XV International Congress of Entomology
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NOTE TO CONTRIBUTORS

Manuscripts intended for publication in the Philippine Journal of Science should be sent to the Editor, Philippine Journal of Science, National Institute of Science and Technology, P.O. Box 774, Manila, Philippines.

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Manuscripts on biology must be accompanied by abstract for publication in the biological abstracts.

Manuscripts submitted should be typed on one side of white bond paper, 8½" x 11", and double-spaced throughout. One original copy and one carbon copy of manuscripts should be submitted.

Illustration should accompany manuscripts on separate sheets. Photographs should be sent unmounted, with serial number written on back to correspond with list of captions.

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